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Ambrosia Beetles of the Tribe Xyloterini (Coleoptera: Scolytidae) in North America[1]

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The tribe Xyloterini is widely distributed in the Holarctic realm. It is comprised of three rather small but well known genera. The largest of these, *Trypodendron* Stephens, consists of about a dozen species and occurs throughout the Holarctic realm; five of these species occur in North America. *Dendrotrypum* Schedl contains six species that are known only from eastern Asia. *Xyloterinus* Swaine contains one species from eastern North America.

All species in the tribe bore into the woody tissues of the host tree, where they feed largely upon the ambrosial fungus that stains the walls of their burrows. They breed in the larger parts (more than four inches in diameter) of both coniferous and deciduous trees and, as is common with other ambrosia beetles, many species reproduce in a wide variety of unrelated host species. For example, in North America *Trypodendron lineatum* is known to breed in at least eight coniferous and three deciduous host genera, and *Xyloterinus politus* in nine deciduous and three coniferous genera. However, normally a certain degree of host preference is manifest even in these essentially polyphagous species.

The entrance gallery is constructed by the female. It penetrates the bark and extends into the sapwood, where it may branch several times. The larvae are reared in separate chambers arranged in series above and below the main tunnel. These chambers, or cradles, are enlarged by the larvae as they mature and when complete are just large enough to accommodate the mature beetles. In *Xyloterinus* there are two series of cradles above and two below the main gallery; in *Trypodendron* there are only one series above and one below. The young adults leave the brood tree through the parent entrance gallery. Apparently they may overwinter either on the forest floor or in their burrows; evidently there may be either one or two generations each year. The beetles are monogamous; mating may occur on the surface of the bark before the entrance tunnel is started, or at any time during the breeding season.

The economic loss caused by these wood-boring ambrosia beetles is sometimes tremendous. They normally attack only weakened or dying trees; consequently, freshly cut logs are very attractive to them. The black stain produced by the ambrosial fungus always associated with the beetles discolors the wood for some distance around the burrow and together with the gallery holes in the lumber, seriously reduces the quality of lumber from such logs. When severe, the damage may render the lumber commercially valueless.

History

As originally described by Stephens (1830:353), the genus *Trypodendron* included two species, *Dermestes domesticus* L. and *Bostrichus dispar* Fabr. Eight years later Westwood (1838:39) designated *domesticus* as type of the genus. Presumably unaware of Stephens' genus, Erichson (1836:60) described *Xyloterus* for three species, *Dermestes domesticus* L., *Bostrichus lineatus* Oliv., and *Bostrichus 5-lineatus* Adams. The type of *Xyloterus* was later designated as

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Bostrichus lineatus Oliv. by Thomson (1859:146), who, on the same page, also recognized the genus *Trypodendron*. Several authors, including Ferrari (1867:8-9), recognized both genera; however, more recent writers have considered them synonymous and used either one name or the other. Although the name *Trypodendron* had priority, an objection to its use arose because of gross errors in the original diagnosis. In spite of this, the name was properly validated and must continue to be recognized in favour of *Xyloterus*.

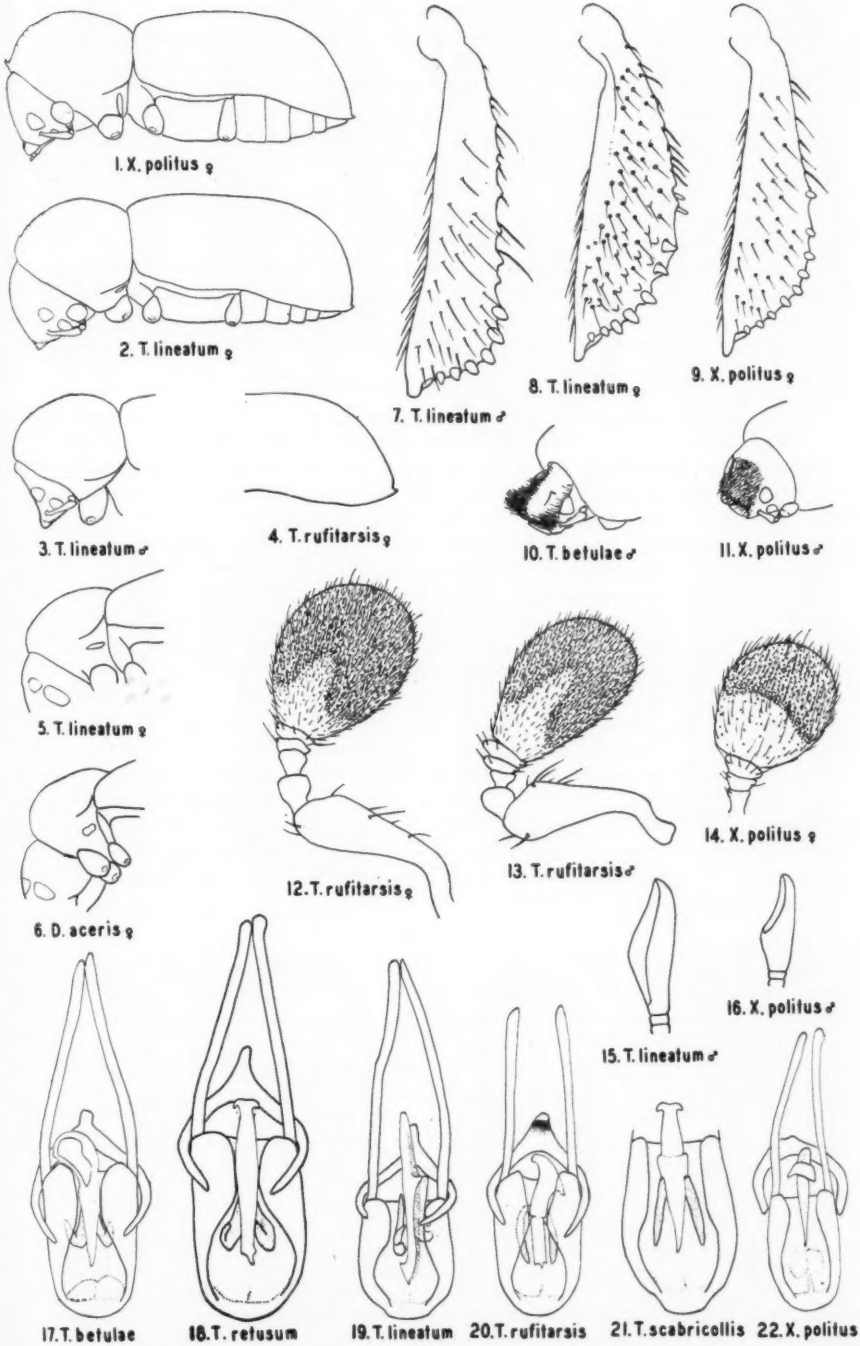
The group of beetles designated by the name *Trypodendron* (or *Xyloterus*) was recognized very early as representing a distinct subdivision of the Scolytidae. A name, Xyloteroideae, was first applied to it by Lindmann (1876:165). Since that time it has been recognized as a distinct group equivalent to a tribe by virtually all authors except Hagedorn (1910:114), who placed it in Xyleborinae, and Hopkins (1915:224) and his followers, who included it in Corthylinae. Only two divisions within the Xyloterini have been made. The first occurred with the recognition of the monobasic Nearctic genus *Xyloterinus* by Swaine (1918:83); the second was made when Schedl (1951:76) erected the oriental genus *Dendrotrypum*.

Intraspecific Variation

Sexual differences are conspicuous in all three genera. In all of them the females have a conspicuous proepimeral excavation (Figs. 1, 2, 5, 6) that is usually ornamented by setae; the cavity is not evident in the males. The female frons is convex in all three genera; it is flattened in the males of *Xyloterinus* (Fig. 11) and *Dendrotrypum*, and is deeply excavated in the males of *Trypodendron* (Figs. 3, 10). The females of *Xyloterinus* are conspicuously larger than the males (Figs. 33, 34); the females of *Trypodendron* are also larger than the males but principally because the pronotum is shortened and subquadrate in the male rather than subcircular as in the female (Figs. 23, 24, etc). The median area of the anterior margin of the pronotum is evenly rounded in the females of *Dendrotrypum*, but is rather strongly produced in the males. The anterior tibiae of *Trypodendron* females are subinflated and tuberculate (Fig. 8); they are flattened and devoid of tubercles in the males (Fig. 7).

Variations between individuals of a particular sex and species were observed in size, colour, and sculpture. The size, determined by measuring the length by means of an ocular micrometer, generally varies much less in ambrosia beetles than in bark-boring scolytids. The difference in length between the largest and smallest available specimen was found to vary from 7 per cent (*Xyloterinus politus* males) to 26 per cent (*Trypodendron betulae* males) of the length of the smallest specimen, the average variation for each sex of the six North American species being 14 per cent. Variation in colour evidently depended upon the age of the specimen more than any other factor. For example, teneral specimens of *T. retusum* (Fig. 26) varied from yellow to striped to the mature black colour (Fig. 25). Specimens from a series of any one species

Figs. 1-16.—*Trypodendron*, *Dendrotrypum*, and *Xyloterinus* spp.: 1, *X. politus*, lateral aspect of female; 2, *T. lineatum*, lateral aspect of female; 3, *T. lineatum*, lateral aspect of anterior parts of male; 4, *T. rufitarsis*, lateral aspect of elytral declivity of female; 5, *T. lineatum*, ventrolateral aspect of proepimeral area of female; 6, *D. aceris*, ventrolateral aspect of proepimeral area of female; 7, *T. lineatum*, posterior aspect of anterior tibia of male; 8, *T. lineatum*, posterior aspect of anterior tibia of female; 9, *X. politus*, posterior aspect of anterior tibia of female; 10, *T. betulae*, anterolateral aspect of head of male; 11, *X. politus*, anterolateral aspect of head of male; 12, *T. rufitarsis*, cephalic aspect of antenna of female; 13, *T. rufitarsis*, cephalic aspect of antenna of male; 14, *X. politus*, cephalic aspect of antenna of male; 15, *T. lineatum*, lateral aspect of antennal club of male; 16, *X. politus*, lateral aspect of antennal club of male.


1. X. politus ♀
2. T. lineatum ♀
3. T. lineatum ♂
4. T. rufitarsis ♀
5. T. lineatum ♀
6. D. aceris ♀
7. T. lineatum ♂
8. T. lineatum ♀
9. X. politus ♀
10. T. betulae ♂
11. X. politus ♂
12. T. rufitarsis ♀
13. T. rufitarsis ♂
14. X. politus ♀
15. T. lineatum ♂
16. X. politus ♂
17. T. betulae
18. T. refusum
19. T. lineatum
20. T. rufitarsis
21. T. scabricollis
22. X. politus

emerging from hibernation at a particular locality were essentially similar in colour; however, these mature specimens often appeared sufficiently different in colour and colour pattern, when compared with teneral specimens of their own brood, to represent a different species. Considerable variation in sculpture, apparently independent of sex or age, was observed in all six North American species. The depth, spacing, and diameter of strial punctures were particularly confusing. Except in *T. scabricollis*, where the punctures were sharply and regularly impressed, the strial punctures varied from large and rather conspicuous to complete obscurity. A waxy or oily substance on the elytra, presumably coming from the walls of the tunnels, may have contributed to this apparent variation. The weak declivital sulci of *Trypodendron* species were so shallow that very minor variations completely changed their appearance. Not only did these sulci vary considerably between specimens of a series, but the difference between the sulci of the left and right elytra of one specimen sometimes appeared greater than the apparent difference between any two of the five native species.

Geographic Variation

The distinguishing characters of the species of *Trypodendron* were often so obscure that it was rather difficult to identify certain specimens without first dissecting and examining the male genitalia. Partly because of this, and partly because of extreme individual variation in colour and in details of surface sculpture, variations that could be correlated with distribution were not readily detected. However, one character that appeared to vary geographically was the colour of *T. lineatum*. Of 229 specimens examined from southern British Columbia, 70 were unicolorous, about a third of these being almost uniformly black; many of the striped specimens from that area also appeared much darker than is normal for the species, but were not considered unicolorous. Of 204 specimens from Quebec and New Brunswick only three could be classed as unicolorous, and only one of these almost uniformly black. The stripes of the eastern specimens were usually more sharply defined than most of those from the west. The ratio of unicolorous to striped specimens from Alberta to Ontario appeared to be intermediate between these extremes, but the high percentage of teneral specimens made an accurate count of the variations inadvisable. Although the difference in colour between the eastern and western series was obvious, even in teneral specimens, it should be pointed out that a higher percentage of the western specimens had spent a winter in hibernation than those from the east.

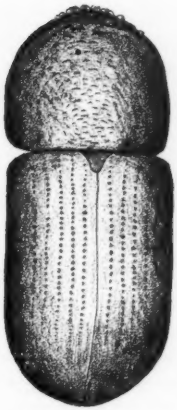
Discussion of Characters

The genera of Xyloterini may be readily distinguished by characters of the antennae. The club of *Xyloterinus* appears obliquely truncate (Figs. 15, 16), but has the basal area less corneous and somewhat more pubescent than usual; in outline it is symmetrical. In *Trypodendron* the club is rather similar to that of *Xyloterinus*, but is more elongate and the central portion of the subcorneous area is rather strongly and narrowly produced toward the apex (Figs. 13, 14); in outline it may be asymmetrical with the outer distal angle produced. The club of *Dendrotrypum* is similar to that of *Xyloterinus*, but is not thickened basally and appears uniformly membranous throughout; in outline it is symmetrical.

Figs. 17-22.—*Trypodendron* and *Xyloterinus* spp., dorsal aspect of male genitalia: 17, *T. betulae;* 18, *T. retusum;* 19, *T. lineatum;* 20, *T. rufitarsis;* 21, *T. scabricollis;* 22, *X. politus.*

Figs. 23-34.—*Trypodendron* and *Xyloterinus* spp., dorsal aspect: 23, *T. scabricollis* male; 24, *T. scabricollis* female; 25, *T. retusum* male; 26, *T. retusum* teneral female; 27, *T. betulae* male; 28, *T. betulae* female; 29, *T. lineatum* male; 30, *T. lineatum* female; 31, *T. rufitarsis* male; 32, *T. rufitarsis* female; 33, *X. politus* male; and 34, *X. politus* female.

23. T. scabricollis ♂

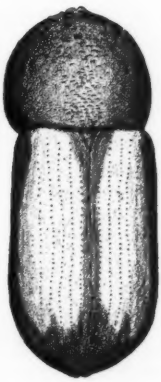


24. T. scabricollis ♀

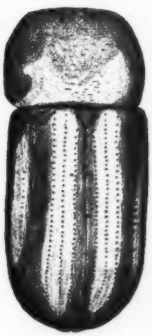
25. T. retusum ♂

26. T. retusum ♀

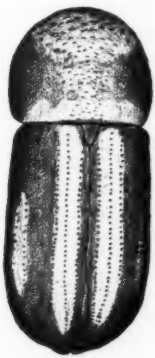
27. T. betulae ♂



28. T. betulae ♀



29. T. lineatum ♂



30. T. lineatum ♀

31. T. rufitarsis ♂

32. T. rufitarsis ♀

33. X. politus ♂

34. X. politus ♀

In the generic classification the sexual differences, mentioned in connection with intraspecific variation above, were also useful, as were the sculpture of the head and shape of the pronotum of the male (Figs. 3, 10). In the female, the shape of the proepimeral excavation (Figs 2, 5) and features of the anterior tibiae (Figs. 8, 9) were also of value. The long axis of the proepimeral excavation of *Trypodendron* is longitudinal and very narrow (Figs. 2, 5); it is longitudinal, short, and rather wide in *Dendrotrypum* (Fig. 6); and it is transverse and wide in *Xyloterinus* (Fig. 1). The anterior tibiae of *Trypodendron* females are subinflated and asperate on the posterior surface (Fig. 8); they are flat and very finely asperate in the male (Fig. 7). The anterior tibiae in *Dendrotrypum* and *Xyloterinus* (Fig. 9) are flat and the posterior surface is smooth.

The classification of the genus *Trypodendron* was formerly based, to a large extent, on rather obscure differences of colour and colour pattern. In an effort to discover more reliable characters a detailed study of both external and internal characters was made. Several useful characters that were overlooked by previous writers were found. Of these, the most consistent and easily recognized differences are in the male genitalia (Figs. 17-21). The genitalic differences are largely limited to the sclerotized structure at the apical end of the ductus ejaculatorius, normally resting inside of the genital capsule. When the genitalic characters alone were used to sort series of associated males and females other differences became obvious immediately. Under a magnification of about 70 diameters the elytral interspaces were observed to be smooth and shining, but punctured by numerous, confused, very minute pores in *T. scabricollis*, *T. retusum*, and *T. lineatum;* in *T. betulae* and *T. rufitarsis* the interspaces were minutely reticulate and appeared dull. The anterior margin of the female pronotum was armed by a series of about four teeth in *T. scabricollis*, *T. retusum*, and *T. betulae;* it was unarmed in *T. lineatum* and *T. rufitarsis*. The extent to which colour may be relied upon also became apparent. The mature colour of adults emerging from hibernation was: black in *T. retusum* (and some of *T. lineatum*); brown in *T. scabricollis* and *T. rufitarsis;* dark brown to black with a pale yellowish-brown stripe between interspaces two and seven that extends from the base of the elytra to the declivital margin in *T. betulae;* and dark brown to black with pale yellowish-brown stripes on interspaces two to four, and on seven in *T. lineatum* (the pale areas were reduced or absent in some specimens). The teneral colour and colour pattern varied extensively with the age of the specimen and became useful only after considerable experience with fully mature specimens had been acquired. Other characters found to be useful in distinguishing individual species are: the presence of a large, pointed median tubercle in the frontal excavation of *T. betulae* males (Fig. 10); the sharply impressed strial punctures and the finely asperate posterolateral areas of the pronotum of *T. scabricollis;* the absence of asperities on the median basal area of the pronotum of most *T. retusum* females; and the difference in lateral profile of the declivity of *T. lineatum* and *T. rufitarsis* (Figs 2, 4).

Phylogeny

The pregula of all species of the Xyloterini is rather strongly depressed below the general posteroventral surface of the head; the antennal club, as clearly seen in *Xyloterinus* (Figs. 15, 16), is a derivation of the obliquely truncate type; and the metepimeron is not covered posteriorly by the elytra (Figs. 1, 2). In addition, the female begins the entrance tunnel; and the male is either smaller than the female or has the frons excavated. The only other groups in the family Scolytidae with this combination of characters are the allies of *Xyleborus* and of *Scolytoplatypus*. From both the morphological and biological evidence it is

clear that the Xyloterini are allied to these groups rather than to the allies of *Corthylus*, which have none of these characters. It is presumed that the *Xyloterini* are somewhat intermediate between the *Xyleborus* and *Scolytoplatypus* groups; however, a detailed consideration of their exact position in relation to these groups must await further study.

Evolution within the Xyloterini is presumably a continuation of that which has proceeded from the more primitive hylesinine type of bark beetle to a form more suitably adapted to the woodboring-ambrosial-fungus-feeding habit (almost ideally exemplified by most Platypodidae). Progressive changes in that direction in the Xyloterini appear to be: modification of the antennal club from obliquely truncate (still observable in *Xyloterinus*) to one that is flat, membranous, and uniformly pubescent (as in *Dendrotrypum*); modification of the flattened anterior tibiae having an essentially smooth posterior face (*Xyloterinus* and *Dendrotrypum*) to one that is subinflated and tuberculate on the posterior face (*Trypodendron*); and loss of the vestiture on the dorsal parts of the pronotum and elytra (*Trypodendron*). Other changes apparently peculiar to the tribe that are correlated with these characters are: modification of the male pronotum and frons; and a change in the long axis of the proepimeral excavation of the female from transverse (*Xyloterinus*) to longitudinal (*Trypodendron*). In almost all cases the more primitive characters, both inter- and intra-tribal, are associated with *Xyloterinus*, and the more specialized with *Trypodendron*. *Dendrotrypum* is intermediate between the two, but is evidently more closely allied to *Xyloterinus*.

The direction of progressive changes that have occurred in the North American species of *Trypodendron* is not clear. The armed anterior margin of the female pronotum in *T. scabricollis*, *T. retusum*, and *T. betulae*; the striped colour patterns of *T. lineatum*, *T. betulae*, and teneral specimens of *T. retusum;* and the presence of a large frontal tubercle in *T. betulae* males are probably of significance in the evolution of the genus. However, consideration of these characters, as well as many others, did not give a clear picture of phyletic relationships; one species appeared to be equally as specialized or as primitive as any of the other four. Examination of two additional European species only increased the problem.

Tribe *Xyloterini*

Xyloteroideae Lindemann, 1876, Bull. soc. imp. nat. Moscou 51:165.
Xyloteri Leconte, 1876, Proc. Amer. Philos. Soc. 15:356.
Xyloteridae Eichhoff, 1878, Mem. soc. roy. sci. Liège, série 2, 8:411.
Xyloterini Reitter, 1913, Wien. ent. Zeit. (Beiheft) 32: 74; Schedl, 1951, Mitt. forstl. Bundes-Vers. Anst. Mariabrunn 47:74.
Xyloterina Balachowsky, 1949, Faune de France 50:196.
Trypodendrinae Trédl, 1907 (in part), Ent. Bl. 3:18.
Xyleborinae Hagedorn, 1910 (in part), Coleopterorum Catalogus 4:97; Hagedorn, 1910 (in part), Genera Insectorum 111:149.
Corthylinae Hopkins, 1915 (in part), U.S. Dept. Agr. Tech. Bull. 17:224.
Corthylini Blatchley and Leng, 1916 (in part), Rhynchophora of North Eastern America, p. 640; Stark, 1952, Fauna U.S.S.R. 31:359.

In the classification of the Scolytidae, as understood at present, the Xyloterini are somewhat intermediate between the allies of *Xyleborus* and of *Scolytoplatypus*. They may be distinguished from these and other groups by the following combination of characters: eye completely divided, pregular area depressed, a proepimeral cavity present in the female, antennal funicle four-segmented, antennal club aseptate and unmarked by sutures but derived from an obliquely truncate type, and metepisternum visible its entire length.

Description.—Length 0.8-4.6 mm.; about 2.5 times as long as wide; body colour varying from reddish-brown to black, some species with alternate dark and pale stripes; vestiture hairlike, rather short and scanty; secondary sexual characters on head or prothorax usually conspicuous.

Head more or less withdrawn into prothorax, not visible from above; front of head convex in the female, varying from slightly flattened to deeply and broadly concave in the male. Eye completely divided into two subequal halves. Antennal scape rather long and club-shaped; funicle four-segmented; club without distinct sutures or septa, the basal area usually thicker, subcorneous, and more sparsely pubescent than the distal area.

Pronotum variable in outline; anteromedian area asperate to behind the summit, the asperities moderately high, rather abundant, broad, and decreasing in size posteriorly; basal margin with a very fine raised line; a rather large proepimeral cavity present in female.

Elytra cylindrical, the basal margins unarmed, and the sides subparallel on more than the basal half; declivity convex, often feebly bisulcate; sculpture variable, usually fine.

Fore coxae contiguous; fore tibiae variable; middle and hind tibiae flattened, with outer margin armed by a series of fine teeth; tarsal segments one to three laterally compressed; abdomen appearing horizontal from lateral aspect.

Key to the Genera of Xyloterini

1. Antennal club (Figs. 12-14) with the subcorneous basal area strongly, rather narrowly procurved; anterior tibiae (Figs. 7, 8) thickened and tuberculate on the posterior face in the female, flattened and finely tuberculate in the male; male head deeply and broadly concave between eyes from epistomal margin to vertex, convex in female; male pronotum subquadrate, the anterior margin straight or slightly recurved and unarmed, female pronotum with the anterior margin rounded (procurved) and armed by marginal teeth; long axis of proepimeral excavation of female longitudinal and very narrow (Fig. 5) ..... *Trypodendron* Stephens

   Subcorneous basal area of antennal club broadly and only feebly procurved, or not at all corneous; anterior tibiae flattened and devoid of tubercles on posterior face in both sexes; frons convex or somewhat flattened in both sexes; anterior margin of pronotum rounded and armed by a series of teeth in both sexes 2

2. Basal area of antennal club not thickened or corneous, uniformly pubescent to base; males and females equal in size; anterior margin of pronotum medially produced in male; long axis of proepimeral excavation of female longitudinal, rather short and broad (Fig. 6); eastern Asia ..... *Dendrotrypum* Schedl

   Basal area of antennal club subcorneous, thickened, and weakly procurved on anterior face (Figs. 15, 16); males distinctly smaller than females; anterior margin of pronotum in male as in female, but usually about half of the marginal teeth reduced or absent; proepimeral excavation of female transverse, rather large, broad (Fig. 1); North America ..... *Xyloterinus* Swaine

Genus *TRYPODENDRON* Stephens

Trypodendron Stephens, 1830, Illustrations of British Entomology, Mandibulata 3:353 (original description); Westwood, 1838 (1840), Synopsis of the Genera of British Insects, p. 39 (type designated); Thomson, 1859, Scandinaviens Coleoptera synoptiskt bearbetade 1:146; Lacordaire, 1866, Hist. Nat. Ins., Gen. Coléoptères 7:377; Ferrari, 1867, Die Forst- und Baumsuchtschädlichen Borkenkäfer, p. 8; Provancher 1877, Petite Faune Entomologique du Canada 1:566; Eichhoff, 1878, Mem. soc. roy. sci. Liège 8:412; Bedel, 1888, Ann. soc. ent. France, hors série, 6:396; Blandford, 1894, Trans. Ent. Soc. London, p. 124; Lovendal, 1898, De Danske Barkbiller, p. 194; Barbey, 1901, Les scolytides de l'Europe centrale, p. 110; Swaine, 1909, New York State Mus. Bull. 134, 24th Rept. State Entomologist for 1908, p. 147; Swaine, 1918, Canadian Dept. Agr. Ent. Br. Bull. 14(2):84; Blackman, 1922, Mississippi Agr. Expt. Sta. Tech. Bull. 11:79; Dodge, 1938, Minnesota Agr. Expt. Sta. Tech. Bull. 132:36, Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 296; Beal and Massey, 1945, Bull. Duke Univ. School Forestry 10:107; Schedl, 1951, Mitt. forstl. Bundes-Vers. Anst. Mariabrunn 47:74; Stark, 1952, Fauna U.S.S.R. 31:360.

Xyloterus Erichson, 1836, Archiv. f.Naturgesch. 2(1): 60 (original description); Küster, 1844, Käfer Europas 4:64; Bach, 1854, Käferfauna für Nord- und Mitteldeutschland, p. 138; Thomson, 1859, Skandinaviens Coleoptera synoptiskt bearbetade 1:146 (type designated as *Bostrichus lineatus* Olivier); Eichhoff, 1864, Berl. Ent. Zeit. 8:36; Thomson, 1865, Skandinaviens Coleoptera synoptiskt bearbetade 7:357; Lacordaire, 1866, Hist. Nat. Ins., Gen. Coléoptères 7:378; Ferrari, 1867, Die Forst- und Baumzuchtschädlichen Borkenkäfer, p. 9; Puton, 1867, Ann. soc. ent. France, serie 4, 7:631; Redtenbacher, 1874, Fauna austriaca, die Käfer 2:382; Leconte, 1876, Proc. Amer. Philos. Soc. 15:357; Reitter, 1894, Verh. Naturf. Ver. Mähren 33: 92; Hubbard, 1897, U.S. Dept. Agr., n.s., Bull. 7: 28; Tredl, 1907, Ent. Bl. 3: 19; Niisima, 1909, Jour. College Agr., Sapporo, Japan, 3(2):163; Hagedorn, 1910, Coleopterorum Catalogus 4:114; Hagedorn, 1910, Genera Insectorum 111:157; Reitter, 1913, Wien. Ent. Zeit., Beiheft 32:74; Hopkins, 1915, U.S. Dept. Agr. Tech. Bull. 17:226; Blatchley and Leng, 1916, Rhynchophora of North Eastern America, p. 644; Balachowsky, 1949, Faune de France 50:196.

This genus can be readily distinguished from the allied genera by the asperate posterior face of the fore tibia (Figs. 7, 8), the narrowly and strongly procurved subcorneous basal area of the antennal club (Figs. 12-13), the broadly and deeply concave frons and the subquadrate pronotum of the male (Figs. 23, 25, 27, 29, 31), and the narrow longitudinal proepimeral cavity of the female (Figs. 2, 5).

Description.–Frons convex in the female, broadly and deeply concave from epistomal margin to well above the eyes in the male; antennal club with the subcorneous basal area strongly and rather narrowly procurved. Pronotum subcircular in the female with the anterior margin rather strongly procurved and armed, subquadrate in the male with the anterior margin almost straight or slightly recurved and unarmed; foveate excavation on proepimeral area of female longitudinal, rather narrow. Elytra feebly striate, the interstrial punctures usually obsolete; declivity usually feebly bisulcate; the subapical line sharply elevated, usually visible from above. Anterior tibia subinflated and rather coarsely asperate on posterior face in female, flattened and very finely asperate in male.

Type Species.–Dermestes domesticus L., subsequent designation by Westwood (1838: 39).

Key to the North American Species of *Trypodendron*

1. Pronotum asperate over entire surface, including posterolateral areas; elytral striae with the punctures regular, rather deep, and sharply defined on both disc and declivity ..... *scabricollis* (Leconte)

   Pronotum with posterolateral areas punctate; elytral striae rather obscure, the punctures very shallow, usually visible but not sharply defined on either disc or declivity 2

2. Frons of male armed by a rather large, sharply pointed, median tubercle between upper halves of the eyes; posterolateral areas of pronotum more closely and deeply punctured (particularly on females); pronotum dark brown to black in colour; mature colour of elytra dark brown to black, usually with a pale area extending from elytral base to declivital margin between interspaces two and seven; surface of pronotum and elytra minutely reticulate; male genitalia as figured (Fig. 17); from *Betula* spp. ..... *betulae* Swaine

   Frons of male without a tubercle at centre; posterolateral angles of pronotum very finely, less closely punctured (particularly on females); colour pattern variable, the pronotum often with at least part of the basal area pale 3

3. Larger, males 3.6-4.3 mm., females 3.8-4.6 mm.; female pronotum usually not asperate on median area at base; mature colour black, young adults pale on an area between interspaces two to seven from base to declivital margin and continuing on sides of declivity between interspaces five to seven from base to the apex; surface of elytra smooth, shining; male genitalia as figured (Fig. 18); from *Populus* spp. ..... *retusum* (Leconte)

   Smaller, males 2.7-3.3 mm., females 3.0-3.7 mm.; median area of pronotum asperate to basal margin on both sexes; colour variable, but almost never uniformly black; from coniferous hosts 4

4. Elytral surface smooth and shining, the interspaces usually very minutely and irregularly punctured; elytra more broadly rounded behind, the declivity abrupt (Fig. 2), and the subapical margin appearing broadly rounded from above; colour dark brown to almost black, with pale yellowish-brown markings on base of pronotum and on elytra on interspaces two to four, seven, and on declivity (five dark alternating with four pale longitudinal stripes); the transition in colour from light to dark abrupt; male genitalia as figured (Fig. 19) ..... *lineatum* (Olivier)

Elytral surface rather dull, minutely reticulate; elytra more narrowly rounded behind, the declivity not as steep (Fig. 4), the subapical raised margin appearing subacuminate from above; colour brown, the anterior and lateral areas of the pronotum and the sides of the elytra usually a darker brown, the transition from light to dark gradual; male genitalia as figured (Fig. 20) ..... *rufitarsis* (Kirby)

Trypodendron scabricollis (Leconte)

Figs. 21, 23, 24

Xyloterus scabricollis Leconte, 1868, Trans. Amer. Ent. Soc. 2:158; Leconte, 1876, Proc. Amer. Philos. Soc. 15:358; Eichhoff, 1878, Mem. soc. roy. sci. Liége 8:419; Hopkins, 1893, West Virginia Agr. Expt. Sta. Bull. 31: 134, 32: 210; Hubbard, 1897, U.S. Dept. Agr. Div. Ent. Bull., n.s., 7:29; Hopkins, 1899, West Virginia Agr. Expt. Sta. Bull. 56:444; Skinner, 1905, Ent. News 16:248; Fall and Cockerell, 1907, Trans. Amer. Ent. Soc. 33:217; Hagedorn, 1910, Coleopterorum Catalogus 4:116; Blatchley and Leng, 1916, Rhynchophora of Eastern North America, p. 646.

Trypodendron scabricollis, Provancher, 1878, Additions et Corrections à la Faune coleopterologique de la Quebec, p. 13 (1878, Le Nat. canad. 10:381); Swaine, 1918, Canadian Dept. Agr. Ent. Br. Bull. 14(2):84; Blackman, 1922, Mississippi Agr. Expt. Sta. Tech. Bull. 11:79; Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 299; Beal and Massey, 1945, Bull. Duke Univ. School For. 10:107; Craighead, 1950, U.S. Dept. Agr. Misc. Pub. 657:339.

This species is distinguished from other North American representatives of the genus by the finely and sparsely asperate posterolateral areas of the pronotum, by the sharply impressed strial punctures, by the smooth and shining elytral surface, and by the colouration.

Female.—Length 3.6-4.1 mm., 2.5 times as long as wide; body brown, the basal one-fourth of the pronotum and the elytra between interspaces two and seven usually somewhat lighter in colour.

Frons convex, weakly impressed above epistoma; a short broad carina on lower half reaching epistomal margin; surface rather coarsely granulate; vestiture moderately long, sparse, inconspicuous. Antennal club oval, with the mediodistal margin very slightly produced.

Pronotum 1.1 times as wide as long; sides weakly arcuate and converging toward the broadly rounded anterior margin; anterior margin armed by four teeth, the median pair larger; the asperities decreasing in size posteriorly to the basal margin; posterolateral areas usually finely punctate-asperate; vestiture sparse, inconspicuous.

Elytra 1.7 times as long as wide; sides subparallel on basal two-thirds, rather narrowly rounded behind; strial punctures sharply and deeply impressed on both disc and declivity; interstriae more than twice as wide as striae, the surface smooth and shining, with extremely minute, rather abundant, confused punctures (visible at a magnification of 70 diameters or more). Declivity convex, moderately steep; the strial punctures as on disc, but usually a little smaller; interspace two impressed and narrower than one or three; the subapical margin giving the elytra a subacuminate appearance when viewed from above. Vestiture visible only on declivity, very short.

Male.—Similar to female except: size slightly smaller, length 3.5-3.7 mm., 2.3 times as long as wide; frons broadly excavated from epistoma to vertex, more or less foveate at center in most specimens, lateral margins ornamented by longer, more abundant hair; pronotum subquadrate, 1.4 times as wide as long, the

anterior margin straight and unarmed. Male genitalia as figured (Fig. 21, this illustration was prepared from a damaged genital capsule, the only one available.)

Type Locality.—Washington, D.C.

Hosts.—*Pinus* and *Tsuga*.

Distribution.—The southeastern United States from New York to Mississippi.

Fifty specimens from the following localities were examined:—Mississippi: "A and M", and Trimswamp. *New Jersey*: Brown's Mills Junction, Grenlock, Iona, and "Lahaway." *North Carolina*: Durham and Tryon. *Pennsylvania*: "Pa." *Virginia*: Gloucester County. *West Virginia*: Dellslow, Morgantown, and Pocahontus County.

The above description of the female was made from the third specimen in Swaine's series; the male was described from the first specimen, his homotype. The second specimen of the series, from New Mexico, is of *lineatum*.

***Trypodendron betulae* Swaine**

Figs. 10, 17, 27, 28

Trypodendron betulae Swaine, 1911, Can. Ent. 43:216; Swaine, 1918, Canadian Dept. Agr., Ent. Br. Bull. 14(2) :84, 85; Dodge, 1938, Minnesota Agr. Expt. Sta. Tech. Bull. 132:36; Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 299; Leach, 1940, Phytopathology 30:277; Craighead, 1950, U.S. Dept. Agr. Misc. Pub. 657:339; Nash, 1951, Maine For. Serv. Bull. 15:46.

This species is distinguished from other North American representatives of the genus by the more coarsely punctured posterolateral areas of the pronotum, by the dull, minutely reticulate surface of the pronotum and elytra, by the colour pattern of the mature beetle (Figs. 27, 28), by the presence of a rather large, sharply pointed median tubercle between the upper halves of the eyes of the male (Fig. 10), and by the distinctive male genitalia (Fig. 17).

Female.—Length 3.1-3.5 mm., 2.6 times as long as wide; body colour dark brown to black, with a pale yellowish-brown area between interspaces two and seven extending from base to declivital margin (the pale area larger or smaller depending on the age of the specimen).

Frons convex, a weak transverse impression just above the epistoma; a broad, low median carina extending from epistoma almost to upper level of eyes; surface rather coarsely and sparsely granulate; vestiture sparse, inconspicuous. Antennal club oval, symmetrical in outline.

Pronotum 1.1 times as wide as long, slightly wider than elytra; sides feebly arcuate and indistinctly converging on posterior half; anterior margin armed by two rather large and two small median teeth; asperities decreasing in size posteriorly to base; surface of posterolateral area minutely reticulate and punctured, the punctures comparatively coarse and close, some of them subgranulate; vestiture sparse, short, inconspicuous.

Elytra 1.7 times as long as wide, the sides straight and subparallel on basal two-thirds; striae indicated by indistinct, feebly impressed punctures; surface rather dull, appearing minutely reticulate (under magnification of at least 70 diameters). Declivity convex, moderately steep; interspace two narrower than one or three and rather strongly impressed; interspaces one and three sometimes bearing a few minute granules; the subapical raised line appearing rather narrowly rounded from above.

Male.—Similar to female except: average size smaller, 2.7-3.4 mm., 2.2 times as long as wide; frons broadly excavated from epistoma to vertex, a median carina at center ending dorsally between upper halves of eyes in a rather large, pointed tubercle; lateral margins of frontal excavation ornamented by more numerous, longer hairs; pronotum subquadrate, 1.5 times as wide as long, the anterior margin straight and unarmed. Male genitalia as figured (Fig. 17).

Type Locality.—Ste. Anne de Bellevue, Quebec.

Hosts.—*Betula* spp., rarely from *Alnus incana.*

Distribution.—Eastern North America; it probably occurs throughout the range of White birch.

One hundred and forty-six specimens from the following localities were examined:—*Manitoba*: Aweme. *Ontario*: Black Sturgeon Lake, Ottawa, and Rockcliffe. *Quebec*: Chelsea, Ile Perrot, Laniel, Montebello, and Ste. Anne de Bellevue. *Maine*: Cupsupic. *Massachusetts*: Arlington, and Cambridge. *Minnesota*: Itasca Park. *New Hampshire*: Mount Washington, and Waterville. *New Jersey*: Springfield. *New York*: Cranberry Lake.

The above description of the female was made from the seventh specimen in Swaine's type series; the male was described from the holotype. The second specimen in Swaine's series in his female plesiotype of *retusum.*

Trypodendron retusum (Leconte)

Figs. 18, 25, 26

Xyloterus retusus Leconte, 1868, Trans. Amer. Ent. Soc. 2:158; Leconte, 1876, Proc. Amer. Philos. Soc. 15:357; Eichhoff, 1878, Mem. soc. roy. Liège 8:420; Hopkins, 1893, West Virginia Agr. Expt. Sta. Bull. 31: 134, 32: 210; Hopkins, 1894, Can. Ent. 26:278; Hubbard, 1897, U.S. Dept. Agr. Div. Ent. Bull., n.s., 7:29; Hagedorn, 1910, Coleopterorum Catalogus 4:116; Blatchley and Leng, 1916, Rhynchophora of Eastern North America, p. 645.

Trypodendron retusum, Swaine, 1913, Rept. Ontario Ent. Soc. 43:89; Swaine, 1918, Canadian Dept. Agr. Ent. Br. Bull. 14(2):85; Dodge, 1938, Minnesota Agr. Expt. Sta. Tech. Bull. 132:36; Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 298; Leach, 1940, Phytopathology 30:227; Craighead, 1950, U.S. Dept. Agr. Misc. Pub. 657:339; Hodson, 1951, U.S. Dept. Agr. Lake States For. Expt. Sta. Aspen Rept. 22:9.

This species is distinguished from other North American representatives of the genus by the larger size, by the smooth and shining surface of the elytra, by the colouration, in the female by the absence of asperities in the median basal area of the pronotum of most specimens, and in the male by the genitalic characters (Fig. 18).

Female.—Length 3.8-4.6 mm., 2.5 times as long as wide; body colour uniformly black when fully mature (as in Fig. 25), young adults (Fig. 26) with pale yellowish-brown areas at base of pronotum and on elytra between interspaces two and seven from base to declivital margin and continuing on sides of declivity between interspaces five and seven to apex, the extent of the pale areas depending upon the age of the specimen.

Frons convex, moderately impressed above the epistoma, with a short, broad, rather indefinite median carina above the epistoma; surface rather coarsely and sparsely granulate; vestiture sparse, rather long, inconspicuous. Antennal club oval, with the mediodistal portion very slightly produced.

Pronotum 1.2 times as wide as long; sides weakly arcuate, anterior half of pronotum semicircularly rounded; anterior margin armed by four teeth, the median pair larger; asperities decreasing in size posteriorly to behind summit, very finely and sparsely asperate in basal area (basal area entirely devoid of asperities in about two-thirds of available specimens); posterolateral areas feebly reticulate, finely and sparsely punctured, the punctures not at all granulate; vestiture rather short, and inconspicuous.

Elytra 1.7 times as long as wide; sides subparallel on basal two-thirds, narrowly rounded behind; strial punctures very fine, rather indistinctly and shallowly impressed; interspaces smooth and brightly shining, with extremely minute, rather abundant, confused punctures (visible at a magnification of 40 or more diameters). Declivity convex, moderately steep; strial punctures reduced; interspace two impressed and narrower than one or three; the subapical margin sharply elevated and produced on a portion at apex giving the elytra a subacuminate appearance from above. Vestiture sparse, short, fine.

Male.—Similar to female except; size slightly smaller, length 3.6-4-3 mm., 2.3 times as long as wide; frons broadly excavated from epistoma to vertex, lateral margins ornamented by longer, more abundant hair; pronotum subquadrate, 1.5 times as wide as long, the anterior margin feebly recurved and unarmed, the asperities extending to base of median area. Male genitalia as figured (Fig. 18).

Type Locality.—Canada, the exact locality unknown.

Hosts.—*Populus grandidentata*, and *P. tremuloides*.

Distribution.—Canada and the northern United States; evidently occurring throughout the distributions of the hosts.

Two hundred and forty-nine specimens were examined from the following localities:—*Alberta*: Edmonton, and Medicine Hat. *British Columbia*: Kaslo, and Quamechan Lake (Vancouver Island). *Manitoba*: Aweme, and Riding Mountain National Park. *New Brunswick*: Bathurst (from Spruce), Fredericton, and Oak Bay. *Ontario*: Ottawa, and Sudbury. *Quebec*: Ft. Coulonge, Ile Perrot, Laniel, and Ste. Anne de Bellevue. *Saskatchewan*: Indian Head. *California*: Chester, Lassen National Park, and Plumas County. *Colorado*: Cheyenne Canyon. *Idaho*: Priest River. *Nevada*: Baker. *New Hampshire*: Webster. *New Mexico*: Cloudcroft. *New York*: Elka Park, and West Point. *Oregon*: Klamath. *Utah*: Logan Canyon. *West Virginia*: Dellslow, and Morgantown.

The above description was made from Swaine's homotype of this species.

Trypodendron lineatum (Olivier)

Figs. 2, 3, 5, 7, 8, 15, 19, 29, 30

Bostrichus lineatus Olivier, 1795, Entomologie 4(77):18.

Xyloterus lineatus, Hamilton, 1894, Trans. Amer. Ent. Soc. 21:406; Hopkins, 1899, West Virginia Agr. Expt. Sta. Bull. 56:444; Fall and Cockerell, 1907, Trans. Amer. Ent. Soc. 33: 217; Blatchley and Leng, 1916, Rhynchophora of Eastern North America, p. 646; Hagedorn, 1910, Coleopterorum Catalogus 4:114.

Trypodendron lineatum, Eichhoff, 1878, Mem. soc. roy. Liège 8:417; Hamilton, 1888, Trans. Amer. Ent. Soc. 16:158; Hamilton, 1894, Trans. Amer. Ent. Soc. 21:35, 406; Swaine, 1913, Rept. Ontario Ent. Soc. for 1912:89; Chamberlin, 1918, Oregon Agr. Expt. Sta. Bull. 147:38; Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 300.

Apate bivittata Kirby, 1837, Faun. Bor. Amer. 4:192; Bethune, 1872, Can. Ent. 4:152.

Xyloterus bivittatus, Mannerheim, 1853, Bull. Mosc. 26:236; Leconte, 1868, Trans. Amer. Ent. Soc. 2:158; Eichhoff, 1871, Berl. Ent. Zeit. 15:137; Leconte, 1876, Proc. Amer. Philos. Soc. 15:426; Hubbard and Schwarz, 1878, Proc. Amer. Philos. Soc. 17:643; Schwarz, 1888, Proc. Ent. Soc. Washington 1:80; Hamilton, 1889, Trans. Amer. Ent. Soc. 16:158; Riley and Howard, 1891, Insect Life 3:435; Hopkins, 1894, West Virginia Agr. Expt. Sta. Bull. 35:295; Hopkins, 1894, Can. Ent. 26:278; Chittenden, 1895, Insect Life 7:419; Hubbard, 1897, U.S. Dept. Agr. Div. Ent. Bull. 7:28; Hopkins, 1901, U.S. Dept. Agr. Ent. Bull., n.s., 28:23.

Trypodendron bivittatum, Provancher, 1877, Petite Faune Entomologique du Canada 1:567; Hopkins, 1904, U.S. Dept. Agr. Div. Ent. Bull. 48:16; Currie, 1905, U.S. Dept. Agr. Div. Ent. Bull. 53:71; Swaine, 1918, Canadian Dept. Agr. Ent. Br. Bull. 14(2):85; Craighead, 1924, Canadian Dept. Agr. Ent. Br. Bull. 25:42; Felt, 1924, Manual of Tree Insects, p. 275; Peirson, 1927, Maine For. Serv. Bull. 5:120; Dodge, 1938, Minnesota Agr. Expt. Sta. Tech. Bull. 132:37; Kimmey and Furniss, 1943, U.S. Dept. Agr. Tech. Bull. 851:22; Beal and Massey, 1945, Bull. Duke Univ. School For. 10:107; Craighead, 1950, U.S. Dept. Agr. Misc. Pub. 657:339.

Bostrichus cavifrons Mannerheim, 1843, Bull. Moscou 16:297; Mannerheim, 1852, Bull. Moscou 25:359.

Trypodendron cavifrons, Swaine, 1918, Canadian Dept. Agr. Ent. Br. Bull. 14(2):85; Hopping and Jenkins, 1933, Canadian Dept. Int. For. Serv. Circ. 38, 14 p.; Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 300; Prebble, 1944, British Columbia Lumberman 28(6): 50.

Trypodendron vittiger Eichhoff, 1880 (1881), Die europäischen Borkenkäfer, p. 298; Schwarz, 1886, Ent. Amer. 2:41; Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 302.

Trypodendron borealis Swaine, 1917, Canadian Dept. Agr. Ent. Br. Bull. 14(1):21; Swaine, 1918, Canadian Dept. Agr. Ent. Br. Bull. 14(2):85; Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 301.

This species is distinguished from other North American representatives of the genus by the smooth and shining elytral surface, by the steeper declivity (Fig. 2), with the raised subapical margin appearing broadly rounded when visible from above (Figs. 29, 30), by the colouration (Figs. 29, 30; five dark alternating with four pale longitudinal stripes), and in the male by the genitalic characters (Fig. 19).

Female.—Length 3.0-3.5 mm., 2.5 times as long as wide; body colour (Figs. 29, 30) very dark brown to black, with base of pronotum and interspaces two to four and seven to eight light yellowish-brown to dark brown, the transition from light to dark colour abrupt, the pale areas quite variable in extent, apparently depending upon the age of the specimen as well as other factors (presumably environmental).

Frons convex, weakly impressed above epistoma, with a short, broad rather indefinite median carina above the epistoma; surface reticulate, with rather fine sparse granules; vestiture fine, rather long, inconspicuous. Antennal club oval, with the mediodistral angle slightly produced.

Pronotum 1.2 times as wide as long; sides weakly arcuate, rather broadly rounded in front; anterior margin unarmed, several irregularly placed submarginal asperities present; asperities decreasing in size posteriorly to base; posterolateral area finely reticulate, with sparse, fine, shallow punctures; vestiture fine, sparse, inconspicuous.

Elytra 1.6 times as long as wide; sides subparallel on basal two-thirds, rather broadly rounded behind; strial punctures very fine, rather indistinctly and shallowly impressed; interspaces smooth and shining, with extremely minute, rather abundant, confused punctures (visible at a magnification of 40 diameters or more). Declivity convex, steep; strial punctures reduced; interspace two weakly impressed and slightly narrower than one or three; the subapical margin sharply elevated, scarcely or not at all visible from above, when visible the outline appearing broadly rounded from above. Vestiture sparse, short, fine.

Male.—Similar to female except: size slightly smaller, length 2.7-3.2 mm., 2.4 times as long as wide; frons broadly excavated from epistoma to vertex (Fig. 3), lateral margins ornamented by longer, more abundant hair; pronotum subquadrate, 1.4 times as wide as long, the anterior margin straight and unarmed. Male genitalia as figured (Fig. 19).

Type Locality.—Northern Europe, the exact locality is not known.

Hosts.—Almost any conifer within its range, including species of *Abies*, *Juniperus*, *Larix*, *Picea*, *Pinus*, *Pseudotsuga*, *Thuja*, and *Tsuga*; the series available at this time also include six records from *Alnus*, three from *Betula*, and two from *Malus*.

Distribution.—North Carolina to Minnesota, New Mexico to California, and northward through the coniferous forests to the northern limits of tree growth; also in northern Eurasia.

More than 3,000 specimens were examined from the following localities:— *Alberta:* Athabasca Landing, Edmonton, and Lesser Slave Lake. *British Columbia:* Avola, Blue River, Caycuse River, Copper Mountain, Creighton Valley, Duncan, Englewood, Franklin River, Glacier, Gordon River, Harris Creek, Hope Mountain, Jasper National Park, Kingsvale, Lens Creek, Likely, Lorna, "Mainland" (probably near Prince Rupert), Parker Creek, Pender Harbor, Saanich, Sarita River, Squamish, Stanley Park, Steelhead, Trinity Valley, Vancouver, Vermillion Summit, Vernon, and Victoria. *Manitoba*: Aweme, and Riding Mountain National Park. *New Brunswick*: Bathurst, Maple Grove, Nepisquit River, and "Pisequit Br." *Nova Scotia*: North Range. *Ontario*: Black Sturgeon Lake, Frater, Hymers, Ottawa, and Sudbury. *Quebec:* Chalk River, Ft. Coulonge, Gaspe, Granby, Ile Perrot, Lake Opasatica, Laniel, Memphremagog, and Ste. Anne de Bellevue. *Saskatchewan*: Prince Albert. *Alaska*: Hunter's Bay, and Sitka. *Arizona*: Flagstaff. *California*: Big Bear

Lake. *Colorado*: Newcastle, and Pitkin. *Idaho*: Coeur d'Alene, Kootenai, Lakeview, Pierce, and Prichard. *Maine*: *Camp Caribou, Lewiston, and Orono*. *Montana*: Columbia Falls, Henderson, Lincoln County, and Pine Grove. *Michigan*: Marquette. *Minnesota*: Lake Itasca. *New Mexico*: Cloudcroft, Las Vagas, and Sacramento Mountains. *New York*: Cranberry Lake, Elka Park, and Lake Placid. *North Carolina*: Great Smoky National Park, Pisgah Ridge, and Tryon. *Oregon*: Astoria, Clatsop, Corvallis, Forest Grove, Mary's Peak, Minam National Forest, Mount Ashland, Portland, and Santiam National Forest. *Pennsylvania*: North Mountain, and Philadelphia. *South Dakota*: Elmore. *Utah*: Alta, Beaver, Mammoth Mountain, and Logan Canyon. *Washington*: Buckeye, Easton, Hoquiam, Junction, London, Longmire, Merideth, Nasalle, Randle, Rock Creek and Satsop. *West Virginia*: Bayard, Crow, Davis, Grant County, and Randolph County. *Wyoming*: Yellowstone Lake.

The above descriptions of the male and female were prepared from Swaine's plesiotypes of *bivittatum*. The specimens in his collection under the names *cavifrons* and *borealis* represent normal colour variations of this species. After a careful and fruitless search for morphological and biological differences the writer reluctantly agreed with others (Chamberlin, 1939:300; (?)Schedl, 1951: 100) that the North American *bivittatum* is identical with the Eurasian *lineatum*.

Trypodendron rufitarsis (Kirby)

Figs. 4, 12, 13, 20, 31, 32

Apate rufitarsis Kirby, 1837, Faun. Bor. Amer. 4:193; Leconte, 1868, Trans. Amer. Ent. Soc. 2:177; Bethune, 1872, Can. Ent. 4:152; Leconte, 1876, Proc. Amer. Philos. Soc. 15:426.

Trypodendron rufitarsis, Swaine, 1917, Canadian Dept. Agr. Ent. Br. Bull. 14(1):22, and 1918, 14(2):85; Dodge, 1938, Minnesota Agr. Expt. Sta. Tech. Bull. 132:36; Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 302.

Trypodendron ponderosae Swaine, 1917, Canadian Dept. Agr. Ent. Br. Bull. 14(1):22, and 1918 14(2): 86; Chamberlin, 1918, Oregon Agr. Expt. Sta. Bull. 147:39; Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 301.

This species is distinguished from other North American representatives of the genus by the dull, finely reticulate surface of the elytra, by the colouration by the narrowly rounded posterior outline of the elytra (Figs. 31, 32), in the female by the unarmed anterior margin of the pronotum, and in the male by the genitalic characters (Fig. 20).

Female.—Length 3.4-3.7 mm., 2.6 times as long as wide; body colour brown, the anterior and lateral areas of the pronotum and the sides of the elytra usually a darker brown, the transition from the light to dark colour gradual.

Frons convex, weakly impressed above epistoma, with a short, broad, rather indefinite median carina above the epistoma; surface reticulate, with rather fine sparse granules; vestiture fine, rather long, inconspicuous. Antennal club oval, with the mediodistal angle slightly produced.

Pronotum 1.2 times as wide as long; sides weakly arcuate, rather broadly rounded in front; anterior margin unarmed, several irregularly placed submarginal asperities present; asperities decreasing in size posteriorly to base; posterolateral area finely reticulate, with the sparse, fine, shallow punctures scarcely perceptible; vestiture fine, sparse, inconspicuous.

Elytra 1.7 times as long as wide; sides subparallel on basal two-thirds, narrowly rounded behind; strial punctures very fine, rather indistinctly and shallowly impressed; interspaces dull, minutely reticulate (visible at a magnification of 70 diameters or more). Declivity convex, moderately steep (Fig. 4); strial punctures smaller; interspace two rather weakly impressed and narrower than one or three; the subapical margin sharply elevated and produced on the apical portion giving the elytra a subacuminate appearance from above. Vestiture sparse, short, fine.

Male.—Similar to female except: size slightly smaller, length 2.9-3.2 mm., 2.5 times as long as wide; frons broadly excavated from epistoma to vertex, lateral margins ornamented by longer, more abundant hair; pronotum sub-

quadrate, 1.5 times as wide as long, the anterior margin straight and unarmed. Male genitalia as figured (Fig. 20).

Type Locality.—Boreal America, the exact locality in Canada not known.

Hosts.—*Picea* spp., *Pinus banksiana*, and *P. contorta;* rarely from other trees, including two authentic records from alder.

Distribution.—The coniferous forests of Canada and of the high mountains in the western United States.

Two hundred and twenty-eight specimens were examined from the following localities:—*British Columbia*: Likely, Lorna, Midday Valley, Mount Apex, Peachland, Stanley and Trinity Valley. *Manitoba*: Riding Mountain National Park. *New Brunswick*: Maple Grove, Nictor Lake, and "Pisequit Br." *Ontario*: Black Sturgeon Lake, and Hymers. *California*: Medicine Lake, and Yosemite National Park. *Colorado*: Newcastle. *Idaho*: Centerville. *Montana*: Beaver National Forest. *Oregon*: Cablicore, Detroit, Grant County, Klamath Falls, Pineville, and Whitman National Forest. *Utah*: Logan Canyon, and Mammoth Mountain. *Washington*: Longmire, and Olimpia.

The above descriptions were prepared from Swaine's plesiotypes; they were compared with Kirby's types at the British Museum of Natural History (Swaine, 1917:22). Swaine described *ponderosae* from a male and a female of *rufitarsis;* most of the other specimens before him were dark specimens of *lineatum*. The "constantly darker colour, deep shining black" to which he referred (Swaine, 1917:22) applies to the specimens of *lineatum*, but not to the specimens labeled as the types of *ponderosae* in his collection.

Genus *DENDROTRYPUM* Schedl

Dendrotrypum Schedl, 1951, Mitt. forstl. Bundes-Vers. Anst. Mariabrunn 47: 76.
Trypodendron, Blandford, 1894 (in part), Trans. Ent. Soc. London, p. 124; Stark, 1952, Fauna U.S.S.R. 31:360.
Xyloterus, Niisima, 1909 (in part), Jour. College Agr. Sapporo, Japan, 3(2):163.

The genus *Dendrotrypum* is known only from six east Asian species. It is considered here only because of its significance in the evolution of the tribe. Only one female specimen, *D. aceris* (Niisima), was available for this study.

Genus *XYLOTERINUS* Swaine

Xyloterinus Swaine, 1918, Canadian Dept. Agr. Ent. Br. Bull. 14(2):83; Blackman, 1922, Mississippi Agr. Expt. Sta. Bull. 11:78; Dodge, 1938, Minnesota Agr. Expt. Sta. Tech. Bull. 132:34; Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 285; Beal and Massey, 1945, Duke Univ. School Forestry Bull. 10:106; Schedl, 1951, Mitt. forstl. Bundes-Vers. Anst. Mariabrunn 47:74.

This genus is distinguished from the allied genera by the broadly and weakly procurved subcorneous basal area of the antennal club (Fig. 15), and the rather large, broad, transverse proepimeral excavation of the female (Fig. 1).

Description.—Female distinctly larger than the male. Frons convex in both sexes, although somewhat flattened in the male (Fig. 11). Antennal club with the subcorneous basal area much thicker and broadly procurved (Figs. 14, 16). Pronotum subcircular, with the anterior margin strongly procurved and armed in both sexes (Figs. 33, 34); the foveate excavation on proepimeral area of the female (Fig. 1) rather long and broad, transverse. Elytra with punctures of striae and interstriae distinct; declivity convex. Anterior tibia flattened, with the posterior face smooth in both sexes (Fig. 9).

Type Species.—*Bostrichus politus* Say, monobasic.

Xyloterinus politus (Say)

Figs. 1, 9, 14, 16, 22, 33, 34

Bostrichus politus Say, 1826, Jour. Acad. Nat. Sci. Philadelphia 5:256.
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Xyloterus unicolor Eichhoff, 1871, Berl. Ent. Zeit. 15:136; Hopkins, 1893, West Virginia Agr. Expt. Sta. Bull. 31:134; Hopkins, 1894, Can. Ent. 26:278.

Trypodendron unicolor Eichhoff, 1878, Mem. soc. roy. sci. Liége 8:419.

Female.—Length 3.3-3.7 mm., 2.7 times as long as wide; body colour dark brown.

Frons convex, a weak transverse impression just above epistoma, and a feeble median elevation from epistoma to upper level of eyes; surface of epistoma smooth and shining, reticulate and sparsely, rather coarsely granulate above; vestiture sparse, fine, rather long. Eye completely divided, the subequal halves separated by a distance equal to the width of the upper half; finely granulate. Antennal scape rather long; funicle four-segmented; club as long as scape, oval, the basal area thicker, subcorneous and on the anterior face broadly procurved.

Pronotum very slightly wider than long (1.02 times); sides feebly arcuate on basal two-thirds, subcircularly rounded in front; anterior margin armed by four teeth; the asperities decreasing in size posteriorly, very fine and rather sparse behind summit; surface of posterior and lateral areas reticulate, shallowly, rather finely punctured; vestiture inconspicuous, fine, short, sparse. Proepimeral excavation rather large, about four times as long as wide, the long axis transverse, extending from the posterolateral coxal margin more than two-thirds of the distance toward the sharply margined posterolateral angles of the disc.

Elytra 1.7 times as long as wide, sides subparallel on basal two-thirds, rather broadly rounded behind; striae not impressed, the punctures small, distinctly impressed; interstriae two to three times as wide as striae, smooth, the punctures about half as large as those of striae, shallow, in irregular rows. Declivity rather steep, convex; striae weakly impressed, the punctures somewhat larger than on disc; costal margin sharply raised near apex. Vestiture consisting of sparse, fine, hairlike setae; short on disc, longer and more abundant on declivity.

Male.—Similar to female except: length 2.7-2.9 mm., 2.4 times as long as wide; frons (Fig. 11) more strongly impressed from epistoma to above eyes, only feebly convex; teeth on anterior margin of pronotum usually reduced in size, sometimes obsolete; and the proepimeral excavation poorly developed and smaller. Male genitalia as figured (Fig. 22).

Type Locality.—An unspecified locality in the United States.

Hosts.—*Acer*, *Alnus*, *Betula*, *Carya*, *Castanea*, *Fagus*, *Fraxinus*, *Quercus*, *Picea*, *Pinus*, *Tsuga*, and *Ulmus*. Records from coniferous hosts are comparatively rare.

Distribution.—Eastern North America from New Brunswick to Minnesota and south to Mississippi and northern Florida.

Four hundred and twenty-three specimens from the following localities have been examined:—*New Brunswick*: Fredericton. *Ontario*: Ottawa, Ridgeway, and Toronto. *Quebec*: Chelsea, Granby, Ile Perrot, Lac Tremblant Nord, Montreal, Mount Orford, Plessisville, Quebec, Ste. Anne de Bellevue, and Ste. Hilaire. *District of Columbia*: Washington. *Illinois*: Champlain. *Kentucky*: Cumberland State Park, and Louisville. *Maine*: Brunswick, and Orono. *Maryland*: Bladensburg,and Plummers Island. *Massachusetts*: Cambridge, Framingham, and W. Springfield. *Michigan*: Detroit, and Grand Ledge. *Missis-*

sippi: Luke. *New Hampshire*: Claremont, and Webster. *New Jersey*: Boonton, Morristown, and Orange Mountains. *New York*: Buffalo, Cranberry Lake, Fourth Lake of the Fulton Chain, Ithaca, Syracuse, and West Point. *North Carolina*: Pink Beds. *Ohio*: Cleveland. *Pennsylvania*: Angora, Frankford, and Inglenook. *Virginia*: Jones Creek. *West Virginia*: Bayard, Little Falls, Monongalia County, Morgantown, Wood County, and Wayne County. *Wisconsin*: Madison.

The above descriptions were prepared from specimens collected at Lac Tremblant Nord, Quebec.

Methods

During the course of this study more than 4,200 specimens were examined. Slightly less than 2,000 of these were studied at the U.S. National Museum, at Washington, the remainder were examined at Ottawa. The types of Swaine's *T. betulae*, *T. borealis*, and *T. ponderosae* were examined personally. The writer's concept of *T. scabricollis*, *T. retusum*, and *X. politus* was based on Swaine's homotypes of these species; studies of the types by Hopkins and Blackman supported Swaine's identification of these species. The concept of *T. bivittatum*, *T. cavrifrons*, and *T. rufitarsis* was based on Swaine's plesiotypes of these species; his specimen of *T. rufitarsis* was compared directly with Kirby's types. The identity of *T. vittiger* was determined by a study of Eichhoff's original diagnosis. The concept of *lineatum* was obtained from a study of more than 60 European examples of this species.

All drawings were prepared with the aid of an occular grid.

Acknowledgment

The writer is indebted to Dr. M. L. Prebble, Forest Biology Division, Science Service, Ottawa, for drawing attention to the need for a revision of this important group of ambrosia beetles, and for his assistance in obtaining the cooperation of Forest Biology Division field workers. Of these men the writer wishes to give special thanks to Dr. J. B. Thomas, Sault Ste. Marie, Ontario, and Mr. J. M. Kinghorn, Victoria, British Columbia, for their special efforts in obtaining specimens and ecological data. Acknowledgment is also made to Dr. W. H. Anderson, Insect Identification and Parasite Introduction Section, U.S. Department of Agriculture, Washington, D.C., for his kindness and assistance in making possible a study of the collections at the U.S. National Museum, and to officials at the U.S. National Museum for providing facilities for study and for making their collections available for study.

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A New Genus and Species of *Microgasterinae* (Hymenoptera, Braconidae)[1]

By W. R. M. Mason[2]
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Muesebeckia new genus
Type of genus *Muesebeckia eximius* n. sp.

Head transverse, as broad as thorax; eyes prominent, not hairy; occipital carina absent; antennae far apart near top of eyes; upper face ("frons") very short, nearly horizontal; lower face flattened and broad (Figs. 3, 4); antennae 21- to 23-jointed.

Notaulices present, extending almost to centre of mesonotum but remote from one another; prepectal carina absent; mesopleural furrow long and horizontal.

Venation reduced (Fig. 1); upper end of basal vein strongly curved. Tibial spurs small and weak.

Abdomen elliptical, depressed (Fig. 2); first tergite broad and rugose, remainder of abdomen smooth and polished; ovipositor short.

This genus is most closely related to *Oligoneurus* Szep. and *Paroligoneurus* Mues. With these genera it has in common the highly set antennae, a short and horizontal frons, reduced apical venation, a strongly curved basal vein, and small hind tibial spurs and coxae. It differs from both in number of antennal segments, presence of notaulices, and presence of pigmented but unsclerotized intercubitals.

Muesebeckia eximius new species

Holotype, ♀.—Length 3 mm. Head as in Figs. 3 and 4; the surface smooth and shining with sparse, fine punctures; clypeus impunctate; lower central part of lower face slightly gibbous; ocellar tubercle elevated; clypeus weakly convex, weakly recurved apically; mandibles strongly tapered, the teeth twisted nearly into a vertical plane; antennal flagellum 19-jointed, as long as body, only slightly tapered toward apex; basal joints of flagellum cylindrical, apical joints moniliform; first flagellar joint four times as long as wide, joint 17 twice as long as wide.

Thorax highly polished and finely, sparsely punctate; mesopleuron impunctate, mesopleural furrow irregularly foveolate; metapleuron rugulose below; scutellum flat, scutellar fovea reniform, transverse, and simple; propodeum small, strongly rugose.

Hind coxae short, about three-quarters as long as metapleuron along pleural suture; hind tibial spurs short, the longer as long as apical width of tibia, the shorter about two-thirds as long.

First tergite of abdomen as long as broad, arched, elevated at the sides of the central area, rugose apically, rugulose basally. Second tergite 2.4 times as wide as long, smooth but faintly granular, weakly rugulose on the basal middle, its corners rounded, the anterior ones more strongly so. Membranous margin developed only on posterior part of first tergum and anterior part of second; suturiform impression obsolete laterally; third and following tergites smooth, but partly faintly granular. Subgenital plate smooth, projecting slightly beyond the last tergite, obtusely pointed, the central third rounded-truncate. Ovipositor sheaths about half as long as petiole, four times as long as wide, terete, but acutely pointed at apex; ovipositor decurved.

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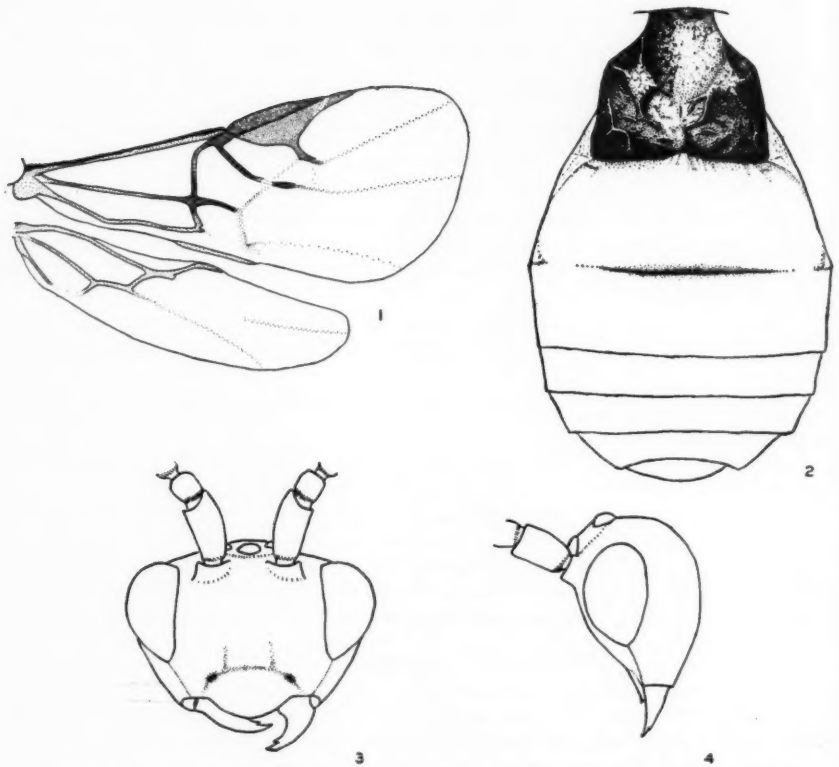
[1]Contribution No. 3505, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada.
[2]Entomologist.



Figs. 1-4. *Muesebeckia eximius* n. sp.—1, wings; 2, abdomen of male; 3, head of female, frontal aspect; 4, head of female, lateral aspect.

Black; membranous margins of tergites one and two, tegulae, wing bases, and mouth parts testaceous; legs, including coxae, testaceous, but hind tibia and tarsus and apical parts of four anterior tarsi infuscated; antenna testaceous, apically infuscated; wing veins and stigma dark brown.

Allotype, ♂.—Similar to holotype but differing in the following details: antenna slightly longer, seventeenth joint 2.5 times as long as wide, flagellum 21-jointed; hind tibia and base of hind tarsus testaceous.

Variation.—Females; specimens from North Carolina with hind legs colored as in allotype; second intercubitus sometimes entirely absent; flagellum 19- to 20-jointed.

Males; apex of hind tibia and entire hind tarsus sometimes infuscated; flagellum 20- to 21-jointed, either intercubitus sometimes absent.

Specimens Seen.—Three females, four males.

Holotype: Female, Blackburn, near Ottawa, Ontario, July 19, 1954, W. R. M. Mason, swept from low, open ground, with a dense growth of willow, spiraea grass, and herbaceous perennials (Canadian National Collection No. 6454).

Allotype: Male, same data as holotype (C.N.C.).

Paratypes: ONT., ♂, same data as holotype but June 29 (C.N.C.). QUE.,

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♂, Wakefield, June 24, 1946, G. S. Walley (C.N.C.). N.C., ♂, 2 ♀ ♀, Pink Beds at 3300 ft. in Pisgah National Forest near Brevard, July 20-21, 1952, G. & L. Townes (George Townes collection).

A male paratype from the Canadian National Collection and a female paratype from the George Townes collection will be deposited in the U.S. National Museum.

Acknowledgment

I wish to thank Mr. George Townes of Greenville, S.C., for the loan of specimens from his collection. I should also like to thank Mr. C. F. W. Muesebeck of the U.S. National Museum, Washington, for making available his notes on the type of *Oligoneurus concolor* Szep., for lending specimens of related genera, and for valuable advice.

Descriptions of Two New Phytoseiid Genera (Acarina: Phytoseiidae), with a Note on *Phytoseius* Ribaga, 1902[1]

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Predacious mites of agricultural and horticultural importance are almost entirely of the family Phytoseiidae Berlese, 1913. These mites have received considerable attention both biologically and systematically in recent years, since the discovery that they feed on phytophagous mites of the family Tetranychidae that are of economic importance in many parts of the world.

Nesbitt (1951) revised the family in part, and present knowledge of the Phytoseiidae is largely based on his work. Garman (1948) devised a system of chaetotactic nomenclature that was used by both Nesbitt (*loc. cit.*) and Evans (1952) and is followed in this paper.

The material described herein was found in a collection of mites loaned to the author for identification by the U.S. National Museum, where type material will be deposited. Paratypes will be deposited in the Canadian National Collection.

Proprioseius gen. n.

Type: *Proprioseius meridionalis* sp. n.

Body of each sex covered by a single dorsal shield bearing 14 pairs of setae, many of which are slightly club-shaped and strongly serrated. Seta D5 absent and only seven pairs of lateral setae present, seta L5 standing alone and setae L6 and L7 being together on the posterior third of the body. In the female, the sternal shield with three pairs of simple setae, and the ventri-anal shield with three pairs in addition to the para- and post-anal setae. In the male, the large ventri-anal shield with four pairs of setae and the movable digit of the chelicerae with a spur-shaped spermatophore. In both sexes, the peritrematal plates extending beyond the posterior margin of the fourth coxae.

Proprioseius resembles most closely those phytoseiid genera with not more than 20 pairs of setae on the dorsal shield, i.e., *Typhlodromus* Scheuten, 1857, *Amblyseius* Berlese, 1914, *Phytoseius* Ribaga, 1902, and *Phytoseiulus* Evans, 1952. *Proprioseius* may be distinguished from *Typhlodromus*, *Amblyseius*, and *Phyto-*

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seiulus by the shapes and character of many of the lateral setae and of M2 on the dorsal shield: the former are club-shaped and strongly serrated whereas in *Typhlodromus* and *Amblyseius* they are normal and not more than slightly serrated (Chant, 1955, indicated that the degree of serration may depend upon the season), and in *Phytoseiulus* they are extremely long, slender, and only slightly serrated. In *Phytoseius* the setae of the dorsal shield are strongly serrated but not club-shaped, and the sacral seta S1 is on the dorsal shield near L4 and L5 in both sexes (Evans, 1954, showed that this is the case with all male Phytoseiidae, but not as a rule with the females). The dorsum of both *Phytoseius* and *Proprioseius* is deeply sculptured in both sexes, though this does not necessarily apply to members of the other genera.

The club-shaped, serrated setae on the dorsal shield in *Proprioseius* are unique among the Phytoseiidae.

***Proprioseius meridionalis* sp. n.**

The dorsal shield does not noticeably differ in shape from those of other members of the family.

Female: length 277 μ; width 175 μ. Dorsal shield with 14 pairs of setae: seven in a lateral series (L), five in a dorsal series (D), and two in a median series (M) (Fig. 1). Setae L4 (56 μ long), L7 (69 μ, Fig. 2), and M2 (66 μ) longest on shield, distinctly club-shaped, and strongly serrated. Setae L3, L5, and L6 (averaging 23 μ) noticeably shorter than other lateral setae and not strongly serrated. Dorsal and median setae other than M2 short and nearly smooth. Seta D5 absent. Dorsum deeply sculptured. Sacral setae S1 and S2 on interscutal membrane, both strongly serrated and somewhat club-shaped.

Ventral surface (Fig. 3) covered by the usual shields arranged in the usual manner; gnathosoma and maxillary palps normal for the group. Fixed digit of chelicerae with five or six teeth and pilus dentilis; movable digit with one tooth. Two parapodal plates present: one very long and slender, the other small and ovoid. Ventri-anal shield (73 μ long) with three pairs of setae in addition to para- and post-anal setae; shield almost triangular, longer than broad, with a slight 'waist' posterior to last pair of preanal setae. Four pairs of setae surrounding ventri-anal shield, one pair (VL1) long, club-shaped, and strongly serrated.

Male: length 233 μ; width 150 μ. Chaetotactic pattern of dorsal shield as in female except S1 and S2 on dorsal shield instead of on interscutal membrane.

Ventri-anal shield (87 μ long) bearing four pairs of setae in addition to para- and post-anal setae. Chelicerae with spur-shaped spermatophore.

The type material, two females and two males, was collected at Homestead, Florida, U.S.A., from *Psychotria bahamensis* on October 20, 1948, by Mr. O. D. Link.

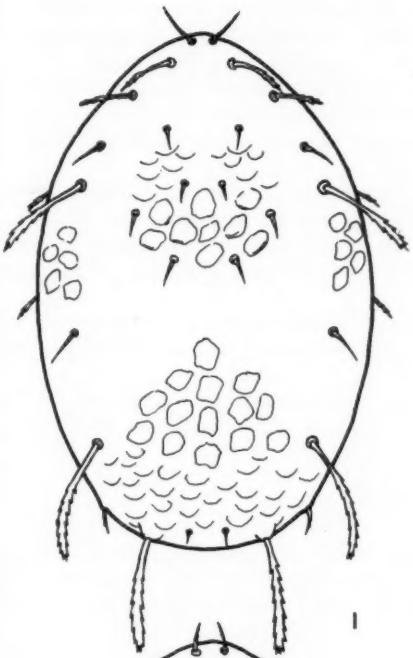
***Proprioseius clancyi* sp. n.**

Female: length 290 μ; width 160 μ. Dorsal shield with 14 pairs of setae: seven in a lateral series, five in a dorsal series, and two in a median series (Fig. 4). Setae M2 and L7 the longest (49 μ and 59 μ respectively), the other lateral setae approximately equal in length (23 μ), somewhat club-shaped and strongly serrated. Dorsal setae and M1 short and nearly smooth. Seta D5 absent. Dorsum deeply sculptured. Sacral setae S1 and S2 on interscutal membrane.

Ventral surface with the usual series of shields; gnathosoma and maxillary

Figs. 1-3. *Proprioseius meridionalis* gen. et sp. n. Adult female: 1, dorsum; 2, seta L7; 3, posterior ventral surface.

Figs. 4-5. *Proprioseius clancyi* sp. n. Adult female: 4, dorsum; 5, posterior ventral surface.



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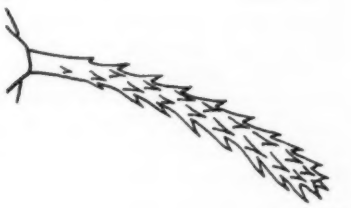

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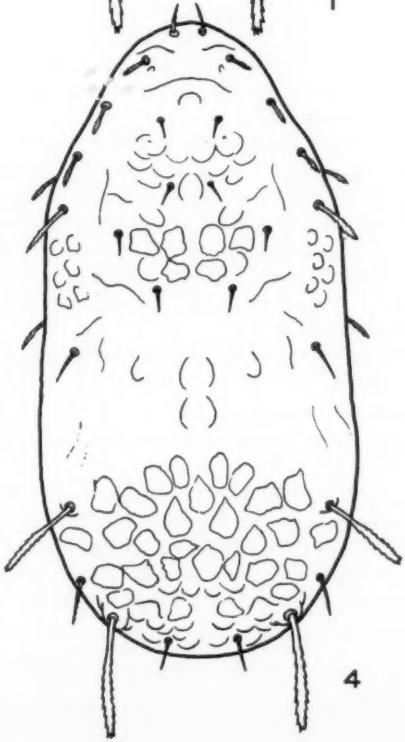

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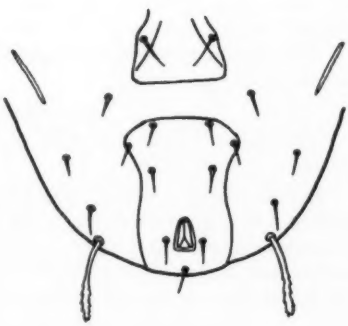

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palps normal for group. Fixed digit of chelicerae bearing five or six teeth and pilus dentilis; movable digit with one tooth. A single long, slender parapodal plate present. Ventri-anal shield (Fig. 5, 87 μ long) with three pairs of setae in addition to para- and post-anal setae and much longer than broad, with a pronounced 'waist' posterior to final pair of preanal setae. Four pairs of setae surrounding ventri-anal shield, of which one pair (VL1) is long, club-shaped, and strongly serrated.

Male: length 242 μ; width 131 μ. Chaetotactic pattern of dorsal shield similar to that of female except sacral setae S1 and S2 here instead of on inter-scutal membrane. Ventri-anal shield (90 μ long) with four pairs of setae arranged as in *P. meridionalis*, in addition to para- and post-anal setae. Chelicerae with spur-shaped spermatophore.

This species may be distinguished from *P. meridionalis* by the relative shortness of seta L4 and by the presence of a pronounced waist on the ventri-anal shield in the female.

The type material, six females and one male, was collected at Kearneysville, W. Va., U.S.A., from wild blackberry on August 7, 1953, by Dr. D. W. Clancy, in whose honour the species is named.

Asperoseius gen. n.

Type: *Asperoseius africanus* sp. n.

Body of each sex covered with a single dorsal shield bearing 14 pairs of setae. Lateral setae only seven in number; lateral setae, D1, D4, and M2 all serrated and slightly flattened; seta D5 lacking. Setae L5 and L6 close together and L7 the only lateral seta on the posterior third of the body. In the female the sternal shield bears three pairs of setae and the metapodal plates one pair. The ventri-anal shield bears three pairs of setae in addition to the para- and post-anal setae. In the male the ventri-anal shield bears three pairs of setae and the movable digit of the chelicerae bears a horn-shaped spermatophoral organ.

Asperoseius differs from *Typhlodromus* and *Amblyseius* in the forms of the lateral setae and of M2, D1, and D4 and in lacking D5, and from *Phytoseiulus* in the forms of the lateral setae. It differs from *Phytoseius* in the same respects as does *Proprioseius* (see above) and from *Proprioseius* in having flattened, strongly serrated setae of approximately equal diameter throughout their lengths; *Proprioseius* has strongly serrated, club-shaped setae that are round in section and have their greatest diameter distally. The dorsum of the new genus is strongly sclerotized and moderately ornamented.

The flattened, strongly serrated setae in *Asperoseius* are unique among the Phytoseiidae.

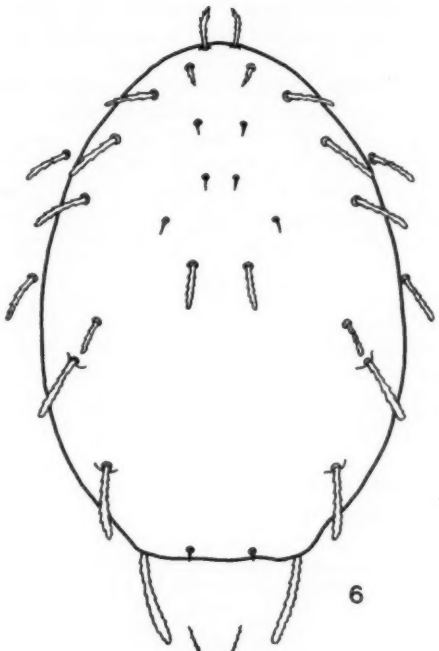
Asperoseius africanus sp. n.

The dorsal shield does not noticeably differ in shape from those of other members of the family.

Female: length 438 μ; width 255 μ. Dorsal shield with 14 pairs of setae: seven in a lateral series, five in a dorsal series, and two in a median series (Fig. 6). All lateral setae and D1 (Fig. 7), D4 (23 μ long), and M2 (42 μ long) strongly serrated and flattened. No lateral setae greatly longer than others, but D4 much longer than remaining dorsal setae. Setae L5 and L6 close together, and seta L7

Figs. 6-8. *Asperoseius africanus* gen. et sp. n. Adult female: 6, dorsum; 7, seta D1; 8, posterior ventral surface.

Figs. 9-11. *Phytoseius plumifer* (C. & F.). 9, dorsum; 10, leg IV; 11, posterior ventral surface.



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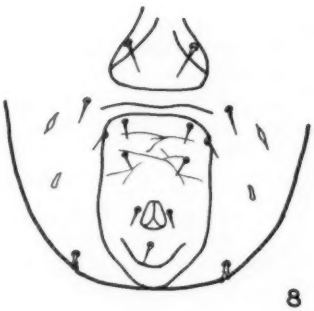

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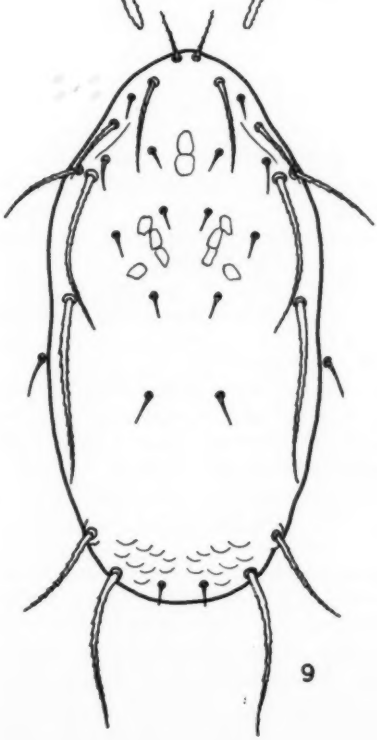

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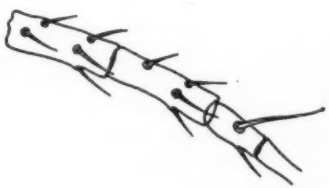

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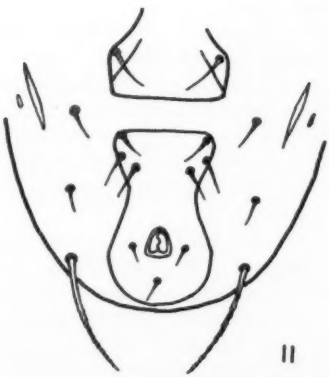

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(56 μ) the only lateral seta on posterior third of body. Setae D2, D3, D5, and M1 short and smooth. Sacral setae S1 and S2 serrated and on interscutal membrane.

Ventral surface covered by usual shields; gnathosoma and maxillary palps normal for the group. Fixed digit of chelicerae with three teeth and pilus dentilis; movable digit with one tooth. Two minute parapodal plates present, both longer than broad. Ventri-anal shield (124 μ long) oblong, but rounded posteriorly and with three pairs of setae in addition to para- and post-anal setae (Fig. 8). A definite crease on the shield posterior to anus. Two pairs of setae surrounding the ventri-anal shield, of which one pair (VL1) is short, peglike, and moderately serrated.

Male: length 292 μ; width 182 μ. Dorsal chaetotaxy resembling that of female except setae S1 and S2 on dorsal shield instead of on interscutal membrane.

Ventri-anal shield (116 μ long) with three pairs of setae in addition to para- and post-anal setae. Chelicerae with horn-shaped spermatophoral process.

The type material, 13 females and 5 males, was collected on May 17, 1955, at Boston, Mass., U.S.A., from cut flowers imported from South Africa, by Mr. J. D. Crump, Jr.

Phytoseius Ribaga, 1902

Until recently the only generally recognized member of the genus *Phytoseius* was *P. macropilis* (Banks, 1909) (=*Typhlodromus spoofi* Oudemans); this species was described and figured on several occasions (Nesbitt, 1951; Cunliffe and Baker, 1953; Womersley, 1954). In November, 1955, the author studied the Berlese collection of mites at the Stazione di Entomologia Agraria, Florence, Italy. In this collection were two slides (numbers 224/41 and 224/42) bearing four specimens of a species that is undoubtedly valid and undoubtedly belongs to this genus, i.e., *P. plumifer* (C. & F., 1876). Recently, in material sent to the author by Dr. Edward W. Baker of the United States National Museum, Washington, D.C., additional specimens were found that had been collected, from fig leaves imported from Italy, at New York on December 22, 1953, by Messrs. Delgado and Sartor. Berlese's specimens were collected from *Vitis vinifera* L. at Spalato, Italy, and though they are not type specimens it may be assumed that Berlese had access to the collections of Canestrini and Fanzago when he identified them. Because of the general ignorance concerning the existence of this species, and because its importation from Italy may result in its being recorded by collectors in North America, a description of this species is included in this paper.

Phytoseius plumifer (C. & F., 1876)

Female: length 270 μ; width 146 μ. Single dorsal shield with 16 pairs of setae (including S1, which is associated with L4 and L5) arranged in a lateral series of seven pairs; six pairs in a dorsal series and two in a median series (Fig. 9). All lateral setae and S1 and M2 thickened, thornlike, and strongly serrated. M1 and all dorsal setae short and smooth. Dorsum moderately ornamented and setae L5 and L6 arising from slight tubercles. Seta S2 on interscutal membrane. Seta L6 102 μ long.

Ventrally, body covered by the usual shields; gnathosoma and maxillary palps normal for the group. Parapodal plates two in number: one long and slender, the other small and ovoid. Ventri-anal shield (Fig. 11) (89 μ long) shaped as in *P. macropilis* and with three pairs of setae in addition to para- and post-anal setae. Three pairs of setae surrounding ventri-anal shield of which one pair (VL1) is long and slightly serrated.

Male: unknown.

The species differs from *P. macropilis* in having six dorsal setae (D) instead of five, in having an additional seta on the interscutal membrane (S2), and in having the lateral setae and S1 somewhat longer and more slender. Also, *P. plumifer* has only one macroseta on leg IV, on the basitarsus (Fig. 10), whereas *P. macropilis* has three, on the genu, tibia, and basitarsus.

Acknowledgments

The author is greatly indebted to Dr. Edward W. Baker, United States National Museum, Washington, D.C., for the loan of the material from which these descriptions were made, and to Prof. Antonio Melis, Director, Stazione di Entomologia Agraria, Via Romana, Florence, Italy, for permission to study the Berlese collection of mites.

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Effect of Continuous Rearing in Rescue Wheat on Survival of the Wheat Stem Sawfly, *Cephus cinctus* Nort. (Hymenoptera: Cephidae)[1]

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Rescue wheat has been grown in the prairie regions of Canada and the United States since 1946 as a control for the wheat stem sawfly, *Cephus cinctus* Nort. Although there is no evidence of the existence of a strain of sawflies to which Rescue is not resistant, the possibility of the development of such a strain is an important consideration. Callenbach (1952) found no differences in the percentages of Rescue stems cut by the progenies of sawflies reared the previous year in Rescue and in susceptible varieties of wheat.

The present work was done to determine whether a strain that would survive readily in Rescue wheat could be segregated by rearing sawflies continuously in this variety.

Methods and Materials

In the spring of 1952, a sample of approximately 2,000 stubs containing sawfly larvae collected from Rescue wheat and a sample of 900 from each of the susceptible wheats Red Bobs and Thatcher were each placed in a 10- by 20-foot plot of the same wheat variety from which the stubs had been collected. Each

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[2]Entomologist and Assistant Entomologist.

of the three plots was covered with a plastic screen cage during the flight period to confine the sawflies emerging from these stubs and to exclude the wild population. In the fall, the surviving progeny were collected from each plot and stored in the laboratory until the following spring, when they were placed in a plot of the same variety from which they had been collected the previous year. As the treatments were continued until the fall of 1955, each of the three groups of sawflies was reared for five generations in a single host variety.

A sample of 75 stubs each from the Red Bobs and Thatcher plots was examined for larval parasitism in the fall of 1953.

It had been planned to compare the survivals of all three groups in Rescue alone after the seventh or eighth generation in each of the three hosts but the reduction of numbers in Rescue made this impossible.

Results

By the fall of 1955, the numbers of larvae of *C. cinctus* in the three varieties of wheat after five continuous generations were: Red Bobs, 411; Thatcher, 178; Rescue, 1. The experiment had to be ended in 1955; even if the one individual surviving in Rescue were a female, its offspring would all be males. Parasitism in 1954 and 1955 reduced the numbers in the plots of Red Bobs and Thatcher, but had little effect in Rescue. In 1953, the percentages of larvae parasitized in the stubs were 14 for Thatcher and two for Red Bobs, indicating why the survival was lower in Thatcher than in Red Bobs.

Discussion

The major reduction in the densities of *C. cinctus* was caused by host resistance in Rescue, by parasitism in Red Bobs and Thatcher, and by the effects of caging in all three varieties.

As most parasitism occurs after the end of the sawfly flight and hence after the cages were removed, parasites were able to enter the plots from adjacent sawfly infestations as well as from the stubs buried in the plots.

The resistance of Rescue appears to depend on the pithiness of its stems (Platt and Farstad, 1946; Platt, Farstad, and Callenbach, 1948). However, these stems vary considerably in their pithiness and hence in their resistance. If most of the larvae that survive in Rescue do so because they are in hollower stems and not because they are hardier than those that die, they are not likely to produce a strain to which Rescue is susceptible. Consequently, the segregation of such a strain of sawflies by the intensive use of Rescue may never become a problem in the control of this insect.

Summary

Rearing *Cephus cinctus* Nort. in Rescue wheat for five successive generations failed to segregate a strain of sawflies to which Rescue is susceptible; the numbers of sawflies in this variety were reduced from about 2,000 in 1952 to one in 1955.

Acknowledgments

The writers acknowledge the criticisms and advice of Drs. C. W. Farstad, G. A. Hobbs, and R. W. Salt of the Lethbridge laboratory.

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Factors in Resistance of Peas to the Pea Aphid, *Acyrthosiphon pisum* (Harr.) (Homoptera: Aphididae). I. The Sugar-Nitrogen Ratio[1]

By J. B. Maltais[2] and J. L. Auclair[2]
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St. Jean, Que.

Differences in resistance of varieties of peas to the pea aphid, *Acyrthosiphon pisum* (Harr.), have long ago been shown in the field and by controlled rearings under glass, Russell and Morrison (1924, p. 63) apparently being the first to observe differences. Early investigations at Wisconsin by Searls (1932) showed that pea varieties differ in the number of aphids born upon them. Maltais (1937) corroborated these early findings and reported (1950) the development of a pure-line strain of aphid-resistant pea. The influence of resistance in peas upon aphid development, reproduction, and longevity was investigated by Harrington (1941) with individual plants under controlled conditions in the greenhouse. His results confirmed the inability of the insect to develop and reproduce as fast on a resistant plant as on a susceptible one. It has been postulated that the composition of the available food in the host plant plays possibly the most important role in determining the resistance to aphid attack (Evans, 1938; Painter, 1941). Maltais (1948), Auclair and Maltais (1950), and Maltais (1951) gave preliminary reports on the probable factors in varietal resistance in peas.

This is a report on the determination of total nitrogen, soluble nitrogen, and sugar contents of three susceptible varieties (Perfection, Daisy, and Lincoln) and three resistant varieties (Laurier, Champion of England, and Melting Sugar) of cultivated peas (*Pisum sativum* L.). Results of aphid population counts in the field (Maltais, 1937, 1950, 1951, and unpublished technical report, 1950-1954) for a period of 13 years gave the following average number of aphids per plant sample for each variety: Perfection, 39.6; Daisy, 32.6; Lincoln, 35.0; Laurier (H-103), 9.8; Champion of England, 11.8; Melting Sugar, 16.8.

Methods

The plot system adopted for the growing of the pea varieties in the field was the latin square. Each plot was 15 feet long with four rows 24 inches apart. The plots were separated in all directions by a space 48 inches wide. The seed, treated lightly with Spergon (tetrachloro-*para*benzoquinone) was sown between May 15 and 20. A light application of 2-12-6 fertilizer was made on the surface of the rows after seeding. The peas were also grown in the greenhouse, where the seed was treated with Spergon and placed in wet sand for germination. After one week, in early February, the well-developed and healthy seedlings were placed in loamy soil in 8-inch flower pots. Observations on growth were made periodically and plant samples were collected for analysis at the beginning of April. The stages of plant growth (Table I) were established by counting the internodes of whole plants collected at random at regular intervals, the terminal bud being counted as the first internode. Uninfested plant samples, collected from the field and the greenhouse, consisted of the *terminal growth*, from the terminal bud down to the base of the fourth internode; and of the *middle growth*, from the fifth node down to the base of the sixth internode, each sample being taken from six plants of each of four replicates.

Processing of Fresh Plant Samples

First method: The fresh samples, in glass jars, were frozen in the freezing

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[2]Entomologist.

TABLE I
Average numbers of internodes per plant and stages of growth for six varieties of peas

Sampling date	Stage of growth	Date of seeding: May 15			
		Perfection	Daisy	Laurier	Melting Sugar
June 20	Early growth	9.2	8.5	9.2	9.8
June 27	First blossom	13.2	12.7	14.0	13.6
July 3	Full bloom	14.5	13.0	14.6	15.8
		Date of seeding: May 20			
		Perfection	Lincoln	Laurier	Champion of England
June 19	Early growth	9.0	8.1	8.4	8.9
June 29	First blossom	13.4	13.0	13.0	13.8*
July 3	Full bloom	16.0	15.4	14.8	16.3*
July 7	First blossom				17.4
July 14	Full bloom				21.2

*Early growth stage.

compartment of a domestic refrigerator for eight to twelve hours. The samples were then transferred to open Petri dishes for drying at freezing temperature on the shelves of the refrigerator for three to four weeks. The samples were further desiccated in a vacuum desiccator, ground in a Wiley mill, and stored in air-tight bottles in the dark.

Second method: The fresh samples were quick-frozen at temperatures varying from -50 to -75°C. in a mixture of dry ice (solid carbon dioxide) and acetone, and then dried under high vacuum at freezing temperature. In this process, the samples were transferred from the glass jars to 250-ml. glass containers of the freezing-drying apparatus Virtis (E. Machlett & Son, New York). When sufficiently dried out, the samples were transferred to a vacuum desiccator, ground later in a Wiley mill, and stored in air-tight bottles in the dark. The freezing-drying required about 20 hours under continuous vacuum and the dried samples retained their natural appearance together with the organic constituents unchanged.

These two methods are equally satisfactory, but the second method saves time.

Processing of Dried Plant Samples

Dry matter refers to the totally desiccated and ground plant material.

Water extracts refer to water-soluble biochemical constituents of pea plant samples, and they were prepared as follows: 0.5 gram of dry matter was weighed and an equal volume, or approximately 2.5 grams, of pure fine silica sand was added and ground into a microfine powder in a mechanical mortar (Fisher Scientific Company) for half an hour. The powder was transferred

to a 100-ml. beaker for extraction with 15 ml. of acidulated water (one millilitre of 0.1 normal HCl in 14 ml. water) at room temperature. The mixture was stirred at short intervals during 15 minutes, transferred to centrifuge tubes, heated in a water bath at 100°C. for five minutes, and centrifuged at 2500 r.p.m. for eight minutes. The clear supernatant liquid was measured into portions of 1, 2, and 5 ml. and dried in round-bottom micro-beakers under vacuum, in a desiccator containing granular anhydrous calcium chloride. The evaporated portions keep indefinitely in a desiccator. In its liquid form, the extract was preserved with phenol (0.4 ml. of 80 per cent phenol in 100 ml.).

Methods of Biochemical Analysis

Kjeldahl method: The semi-micro Hengar-Kjeldahl procedure of Henwood and Garey (1936) was used for the determination of the total and soluble nitrogen contents in pea varieties. For the analysis of total nitrogen, samples of 100 milligrams of dry matter were used. For the analysis of soluble nitrogen, aliquots of 2 ml. of the water extract were used. Calculations for the percentage of soluble nitrogen were based on the weight of the dry matter sample represented by one millilitre aliquot of the extract, or

$$\frac{\text{(weight of the sample)} \quad 0.5 \text{ gram}}{\text{(weight of acidulated water)} \quad 15 \text{ grams}} = 0.0333 \text{ gram.}$$

Fehling's reduction method: The Fehling's reduction procedure used was that by Hammond (1940). Analyses of free sugars were made as follows: Measure 2-ml. aliquots of water extract of each variety in 3-ml. centrifuge tubes. Precipitate the proteins with 3 drops of neutral lead acetate saturated water solution. Allow to rest a few minutes and centrifuge three minutes at 3000

TABLE II

Nitrogen and sugar contents (percentages of dry matter) and sugar-nitrogen ratios of terminal growth of susceptible and resistant varieties of peas at two stages of growth, from greenhouse

	(susceptible)		(resistant)	
	Perfection	Daisy	Laurier	Melting Sugar
Total nitrogen				
Early growth	6.02	5.74	4.55	4.48
First blossom	4.69	5.04	3.29	3.92
Soluble nitrogen				
Early growth	3.05	2.63	1.68	1.89
First blossom	1.89	2.10	1.16	1.68
Invert sugar				
Early growth	6.7	11.2	14.6	17.4
First blossom	20.4	19.4	24.3	23.6
Ratio of sugar to total nitrogen				
Early growth	1.1	1.9	3.2	3.9
First blossom	4.4	3.8	7.4	6.0
Ratio of sugar to soluble nitrogen				
Early growth	2.2	4.3	8.7	9.2
First blossom	10.8	9.2	12.0	14.1

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Total nitrogen				
Early growth	6.02	5.74	4.55	4.48
First blossom	4.69	5.04	3.29	3.92
Soluble nitrogen				
Early growth	3.05	2.63	1.68	1.89
First blossom	1.89	2.10	1.16	1.68
Invert sugar				
Early growth	6.7	11.2	14.6	17.4
First blossom	20.4	19.4	24.3	23.6
Ratio of sugar to total nitrogen				
Early growth	1.1	1.9	3.2	3.9
First blossom	4.4	3.8	7.4	6.0
Ratio of sugar to soluble nitrogen				
Early growth	2.2	4.3	8.7	9.2
First blossom	10.8	9.2	12.0	14.1

TABLE III

Nitrogen and sugar contents (percentages of dry matter) and sugar-nitrogen ratios of terminal growth of susceptible and resistant varieties of peas at three stages of growth, from the field

	(susceptible)		(resistant)	
	Perfection	Daisy	Laurier	Melting Sugar
Total nitrogen				
Early growth	5.60	5.88	4.69	5.32
First blossom	5.74	6.03	5.25	3.86
Full bloom	5.12	5.54	3.71	3.86
Soluble nitrogen				
Early growth	2.10	2.52	1.89	2.20
First blossom	3.47	2.94	2.63	2.94
Full bloom	2.31	2.21	1.68	1.57
Invert sugar				
Early growth	12.6	9.6	13.1	13.4
First blossom	4.4	4.4	6.2	10.4
Full bloom	16.4	13.4	22.6	13.9
Ratio of sugar to total nitrogen				
Early growth	2.2	1.6	2.8	2.5
First blossom	0.8	0.7	1.2	2.7
Full bloom	3.2	2.4	6.1	3.6
Ratio of sugar to soluble nitrogen				
Early growth	6.0	3.8	6.9	6.1
First blossom	1.3	1.5	2.4	3.5
Full bloom	7.1	6.1	13.5	8.9

r.p.m. Test with a crystal of neutral lead acetate for complete precipitation. If the precipitation is not complete, add one drop of lead acetate solution, stir and centrifuge again. Precipitate the excess lead acetate with potassium oxalate saturated solution and proceed as in lead acetate for complete precipitation. Centrifuge at 3000 r.p.m. and transfer the clear supernatant in a 30-ml. beaker. Wash residue in the tube, centrifuge and transfer clear washings to respective beaker. For the hydrolysis of non-reducing sugars, add to each cleared sample in beaker 1 ml. of concentrated HCl, cover the container and place in oven at 70°C. for one hour. Neutralize the hydrolyzed sample with sodium hydroxide saturated solution, CO_2-free, using methyl red as indicator and keeping the sample slightly on the acid side with 0.1 normal HCl. For reduction, measure in 100-ml. beakers 30 ml. of diluted 1:1 Fehling solutions A and B. Bring the mixture to boiling, pour the sample in the hot Fehling solutions and allow to boil for two minutes to ensure complete reduction. Filter hot in Gooch filter, wash with hot distilled water 3 times, dry with acetone twice, place in oven at 90°C. for half an hour, cool in desiccator and weigh for Cu_2O. Several samples can be run simultaneously. The results are expressed in terms of percentage of invert sugar based on the 1-ml. aliquot of water extract, or 0.0333 gram dry matter.

The results of biochemical analyses are expressed in terms of total nitrogen, soluble nitrogen, invert sugar, and sugar-nitrogen (S/N) ratio. Each result represents the average from two and four analyses made from a stock consisting of at least 24 plant samples per variety and stage of growth.

TABLE IV

Nitrogen and sugar contents (percentages of dry matter) and sugar-nitrogen ratios of terminal and middle growths of susceptible and resistant varieties of peas at first blossom stage, from greenhouse

	(susceptible)		(resistant)	
	Perfection	Lincoln	Laurier	Champion of England
Total nitrogen				
Terminal growth	6.22	6.88	4.47	4.82
Middle growth	4.29	4.30	2.83	2.38
Invert sugar				
Terminal growth	9.9	6.2	13.7	14.5
Middle growth	8.9	9.9	10.2	14.8
Ratio of sugar to total nitrogen				
Terminal growth	1.6	0.9	3.1	3.0
Middle growth	2.1	2.3	3.6	6.2

Results and Discussion

The results are summarized in Tables II to IV. Student's *t* test showed significant differences at the 5 per cent level between the nitrogen contents of susceptible and resistant varieties and also between the sugar contents of susceptible and resistant varieties.

Nitrogen

The total and soluble nitrogen contents were 11.5 to 37.1 per cent lower in the resistant varieties for corresponding stages of growth and types of plant samples (Tables II and III). Peas at full bloom contained generally less nitrogen than at earlier stages of growth. The average of the total nitrogen in the middle growth of the four varieties was 38.4 per cent less than in the terminal growth (Table IV).

Sugar

According to Bonner (1950, p. 15), glucose, fructose, and sucrose form the principal soluble free sugars of the higher plants, although other sugars may also be found occasionally either in the free state or in combined forms.

There were wide and consistent differences in sugar contents between susceptible and resistant varieties. Free sugars, as expressed in terms of invert sugar, occurred in larger quantities in resistant varieties than in susceptible ones. The differences ranged from 16.2 to 47.0 per cent in all cases for corresponding stages of growth and types of plant samples (Tables II, III and IV).

Sugar-Nitrogen Ratio

The larger quantities of free sugars and the smaller amounts of organic nitrogen in the resistant varieties suggest fairly great nutritional differences for aphids feeding on resistant and susceptible varieties. The sugar-nitrogen ratio in resistant varieties was 23.4 to 63.7 per cent higher than in susceptible ones (Tables II to IV).

The higher ratio of sugar to nitrogen in the resistant varieties supports Schaefer's (1938) hypothesis that aphids must take in large quantities of plant

sap in order to obtain the supply of nitrogenous food necessary for reproduction and must void the excess moisture and carbohydrates. Sugars would apparently be considered unnecessary or slightly utilizable substances for aphid development.

Summary

The nitrogen and sugar contents of three susceptible varieties (Perfection, Daisy, and Lincoln) and three resistant varieties (Laurier, Champion of England, and Melting Sugar) of cultivated peas (*Pisum sativum* L.) were determined at various stages of growth by the Kjeldahl and Fehling methods. The varieties susceptible to the pea aphid, *Acyrthosiphon pisum* (Harr.), contained more nitrogen and less sugar than the resistant varieties, and the sugar-nitrogen ratio (S/N) was 23.4 to 63.7 per cent higher in the resistant ones. This ratio suggests fairly great nutritional differences for aphids feeding on resistant and susceptible varieties of peas.

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The writers wish to thank their colleague Dr. J. J. Cartier for his generous co-operation in the analysis of organic constituents of the plants during the early phase of the work.

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A Virus Disease and Introduced Parasites as Factors Controlling the European Spruce Sawfly, *Diprion hercyniae* (Htg.), in Central New Brunswick[1]

By F. T. Bird[2] and D. E. Elgee[3]

Introduction

An outbreak of the European spruce sawfly, *Diprion hercyniae* (Htg.), was discovered in the Gaspé Peninsula in 1930. By 1938, heavy infestations had developed west of the Gaspé Peninsula in Quebec, throughout New Brunswick and northern Maine, and in parts of Vermont and New Hampshire. Moderate to light infestations occurred through all other parts of the spruce forests of this region and extended from Nova Scotia, to the north shore of the St. Lawrence River, and west to Ontario.

The rate of increase of the sawfly from 1930 to 1938 was irregular chiefly because of annual and regional fluctuations in the percentage of larvae remaining in diapause each year (Prebble, 1941). Populations continued to rise persistently, however, until limited by the supply of foliage. Balch and Bird (1944) attributed the destructiveness of the sawfly up to 1938 to the fact that it became established in a region where its food was plentiful over vast areas, where the climate was favourable, and where the biotic factors of control were insufficient to prevent increases until the factor of food shortage was added. No natural enemies of the egg were found and no important egg mortality resulted from climatic factors. The feeding larval stages were well adapted to the conditions under which spruce grow. Birds and insect predators took a moderate toll of all instars but, as shown by Reeks (1938), native parasites accounted for no more than 0.02%. Although a large number of parasitic insect species were introduced from Europe from 1934 to 1939, only seven became established. Two of these, a cocoon parasite, *Dahlbominus fuscipennis* (Zett.), and a larval parasite, *Exenterus claripennis* (Thom.), exerted considerable control by 1938 (Reeks, 1953). Cocooned sawfly larvae survive temperatures lower than those experienced in the forest floor. They are also resistant to the effects of extreme dry or wet weather. The greatest mortality in the cocoon was caused by small mammals, which destroyed about half the cocoons during a period of outbreak (Morris, 1942). There was little evidence of important control in the adult stage. Most adults apparently succeeded in laying their full complement of eggs.

Early in 1936, small percentages of larvae reared in the laboratory died from disease. The mortality increased steadily until 1939 when it became impossible to rear larvae free from disease in the laboratory. In the forest, only a few larvae that might have been diseased were observed before 1938. During the latter part of this year, diseased larvae became numerous in some parts of New Brunswick and were noted by Dowden (1940) in heavily infested areas in Vermont and New Hampshire. In 1939, mortality was high at these points and was observed over much wider areas. From 1939 to 1942, the disease appeared to spread from south to north. It was not evident in central Gaspé until 1940 and caused no major reduction there until 1942. By 1942, however, it was known to be distributed throughout most of the areas infested by the sawfly, and except for the more northerly areas, the sawfly was reduced to a very low level. Balch and Bird (1944) calculated that if there were no diapause a uniform mortality of 97.8% would be needed in each generation to maintain a static population. Before the appearance of disease, other factors were causing mortality of from

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85 to 95% or more. The parasites, which were increasing rapidly, might have been capable of bringing the "average" generation mortality above 97.8% before scarcity of foliage and dying of trees added the factor of starvation. The disease, however, accomplished this before the potential value of the parasites could be realized and it destroyed so large a proportion of the population that other factors became negligible. Larval mortality from disease in "Plot 1" in 1940 and 1941 was conservatively estimated at 99.7%. In another plot ("Plot 3") an estimated 96.5% and 94.3% of the larvae were killed in the same two years by disease. The total mortality per generation in Plot 3 during these years was estimated at 99.4% and 98.7%, whereas in Plot 1 it was 100%. The disease continued as the dominant factor in the control complex up to 1942. Studies were continued at one of the plots (Plot 3) located near the Acadia Forestry Station in central New Brunswick.

The disease is caused by a polyhedrosis virus that affects the mid-guts of the larvae (Balch and Bird, 1944; Bird, 1949, 1952, 1953; Bird and Whalen, 1954). The origin of the disease in North America is unknown. The suggestion that the virus was introduced from Europe with parasite material (Balch and Bird, 1944) still appears to be the most probable one.

Methods

Most of the data presented in this paper were obtained by using a 10 ft. pole to beat larvae from trees on to a 7 by 9 ft. sheet, collecting the larvae, and rearing them individually in the laboratory. With some exceptions, samples were taken at 7-day intervals beginning June 20 and ending October 1. The sawfly has two generations each year in central New Brunswick and there are two peaks of larval abundance, the first occurring in the middle of July, the second early in September. The late summer population includes both first- and second-generation emergents and its size is influenced by the varying proportion of cocooned larvae that remain in diapause. Since the middle of 1945, precautions have been taken to prevent accidental infection of the larvae. Sheets were sterilized before each sampling period and the larvae were picked up on sterile glass rods and placed individually in sterile rearing vials containing spruce foliage obtained from trees not infested by the sawfly and presumably not contaminated with virus. They were reared in the laboratory at 22°C.

The proportion of a larval sample infected with disease was determined by examining each dead larva for polyhedra. If a larva died from disease within five days, it must have been infected with the virus before sampling since healthy larvae fed heavy concentrations of the virus and reared at 22°C. do not die within this period. Larvae that died in the laboratory six days or more after being collected could have been accidentally infected during collection or while being reared in the laboratory. Although the authors consider mortality caused by accidental infection unlikely, natural infection in a sample was considered questionable if none of the larvae died within five days.

The proportion of a larval sample destroyed by parasites was determined from the number of larvae that survived to spin cocoons and developed into sawfly adults and the number from which parasites emerged. No parasite eggs or larvae were found in virus-killed sawfly larvae. Therefore the question of how to classify mortality in the case of a parasite emerging from a diseased larva did not arise.

The pole-beating technique has many limitations but is considered the best method for obtaining larvae at very low population levels. It gives an estimate of the population and its condition at the time of sampling. It provides no information on the number of larvae that fell before sampling, nor on the number

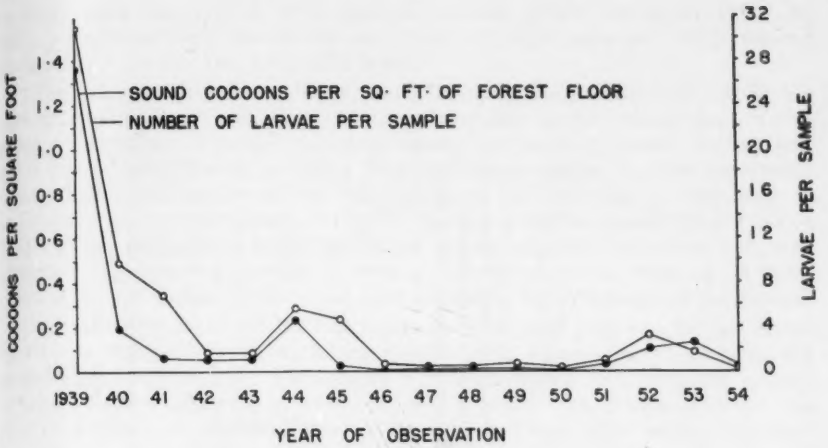

Figure 1

collected that would otherwise have become infected or parasitized. Also, some diseased larvae adhere to the foliage and are difficult to dislodge by beating. The data, therefore, are useful for indicating trends but not for calculating precise generation mortalities.

Estimates of sawfly density were also obtained by sampling the forest floor for cocoons. This was carried out in the same plot as the larval sampling. The plot was established by M. L. Prebble, and his cocoon sampling technique (Prebble, 1943) was used*. It involved collecting all cocoons from 200 one-square-foot quadrats, four beneath each of 50 trees. For the years 1937 to 1951 inclusive, sampling was done in May of the following year. From 1952 on, sampling was done in the autumn of the current year and, therefore, the cocoons were not exposed to predation or to other environmental factors for as long a period.

Results

The population trend of the sawfly from 1939 to 1954, as determined from both cocoon and larval samples, is shown in Fig. 1. In general, the trend obtained by plotting the average number of larvae in the samples each year was similar to that obtained by plotting the much more reliable data from cocoon samples. Discrepancies, such as that recorded in 1945, result from the figures based on larval samples being estimates of the number of larvae present throughout the season whereas the figures based on cocoon samples are estimates of the number of larvae that survive to spin cocoons. In 1945, a severe virus epizootic during the second generation destroyed many of the larvae before cocoons could be spun. Mortality from parasites during the second generation period could not influence the cocoon population figure until the following year since "cocoons" include parasitized as well as healthy sawfly larvae.

An abrupt decline occurred in the number of cocoons spun in 1940 as compared with 1939, and continued in 1941. The population in 1942 and 1943 remained at about the 1941 level. In 1944, there was a resurgence in sawfly numbers followed by a second abrupt decline in 1945. From then until 1951, a relatively stable and extremely low population level was maintained but sawfly

*The authors are indebted to Dr. M. L. Prebble for the cocoon data from 1937 to 1940, and to Dr. R. F. Morris for the data from 1940 to 1944.

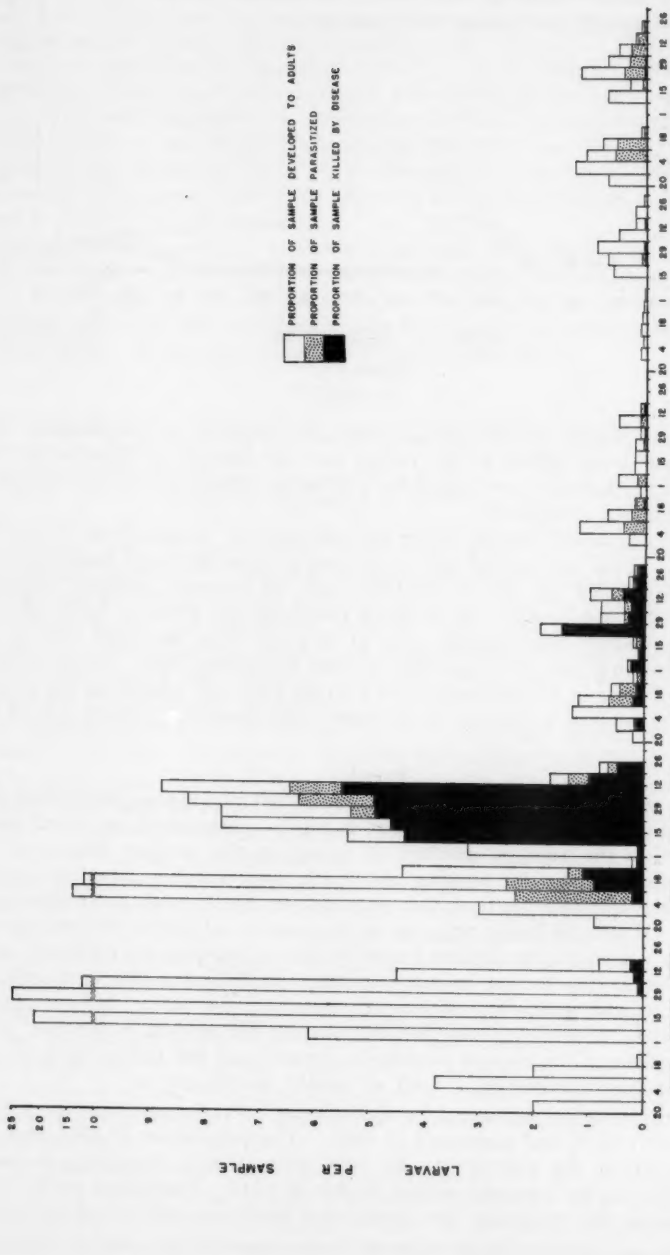
PROPORTION OF SAMPLE DEVELOPED TO ADULTS
PROPORTION OF SAMPLE PARASITIZED
PROPORTION OF SAMPLE KILLED BY DISEASE
LARVAE PER SAMPLE
JULY AUGUST SEPT. 1944
JULY AUGUST SEPT. 1945
JULY AUGUST SEPT. 1946
JULY AUGUST SEPT. 1947
JULY AUGUST SEPT. 1948
JULY AUGUST SEPT. 1949

Figure 2

increases again occurred in 1951 and to a much greater extent in 1952. In 1953, populations were maintained at a relatively high level but were reduced again in 1954 to the low 1945-1951 level.

The evidence that the 1939-1942 decline was caused by the virus disease has been presented (Balch and Bird, 1944), and discussed in the introduction of this paper. The disease, although prevalent among the larvae examined in 1942, was not found affecting larvae in 1943. The population increase in 1944 apparently was a direct consequence of the "disappearance" of the virus in 1943. Figs. 2 and 3 show the average number of larvae at each sampling period from 1944 to 1954 and the proportions killed by disease and by parasites as determined from laboratory rearings, except that in 1944 no information was obtained on parasitism as the gut tissues of all larvae were examined for symptoms of the disease.

No mortality from disease was found in 1944 until very late in the season. In 1945 it occurred early, increased rapidly, and caused heavy losses in the second-generation period. The disease was again prevalent among the greatly reduced numbers of larvae in 1946 but only a "trace" was found in 1947. No positive evidence of disease (larvae dying within 5 days after being collected) was obtained from 1948 to 1951, although during each of these years a "trace" of mortality that could have resulted from field infection was recorded (Table 1, Fig. 1). Positive evidence of field infection was obtained in 1952, 1953, and 1954, showing that the disease persisted during the years of very low host density (Fig. 2).

Until 1951, the effectiveness of the disease appeared to be density dependent, being effective at high and ineffective at low host densities. The chief exceptions were during years following a severe virus epizootic when the disease was effective also at very low host densities. This was observed in 1942 and again in 1946. The reason appears to be that during a severe virus epizootic many insects become infected late in larval development, survive and pass the disease on to their offspring. In areas where there is little tendency towards diapause, the effect would be evident during the year following the epizootic. This and other aspects of virus transmission will be discussed in some detail in a paper on virus diseases of sawflies being prepared by the senior author.

Increases in host density in 1951 and 1952 were not followed by rapid increases in mortality from disease such as occurred following increases in host density of similar magnitude in 1944 and 1945. Whether this resulted from a prolonged period of very low host density from 1945 to 1951 and consequent suppression of virus activity, or from increased resistance of the sawfly to the virus is a problem to be investigated in further field, as well as laboratory, studies. This is the first suggestion of an increase in sawfly resistance to the virus.

The two species of introduced parasites (*D. fuscipennis* and *E. claripennis*) that had become established in this area and were recovered in 1938 and 1939 apparently were eliminated as control factors during the severe virus epizootics of 1940, 1941, and 1942. They have not been recovered at the Acadia Station since 1939 (Table 2). Elsewhere in New Brunswick, small numbers of *E. claripennis* are still being found, but no evidence of *D. fuscipennis* attacking the spruce sawfly has been obtained since 1941 (Reeks, 1953).

The first evidence that other parasite species had become established and survived the virus epizootics that virtually destroyed their host was obtained from cocoon samples in 1944 (Table 2). Since 1944, large proportions of the larvae in larval samples have been parasitized by *Drino bohemica* Mesn. (Tachinidae) and *Exenterus vellicatus* Cush. (Ichneumonidae), (Figs. 2 and 3). They contributed

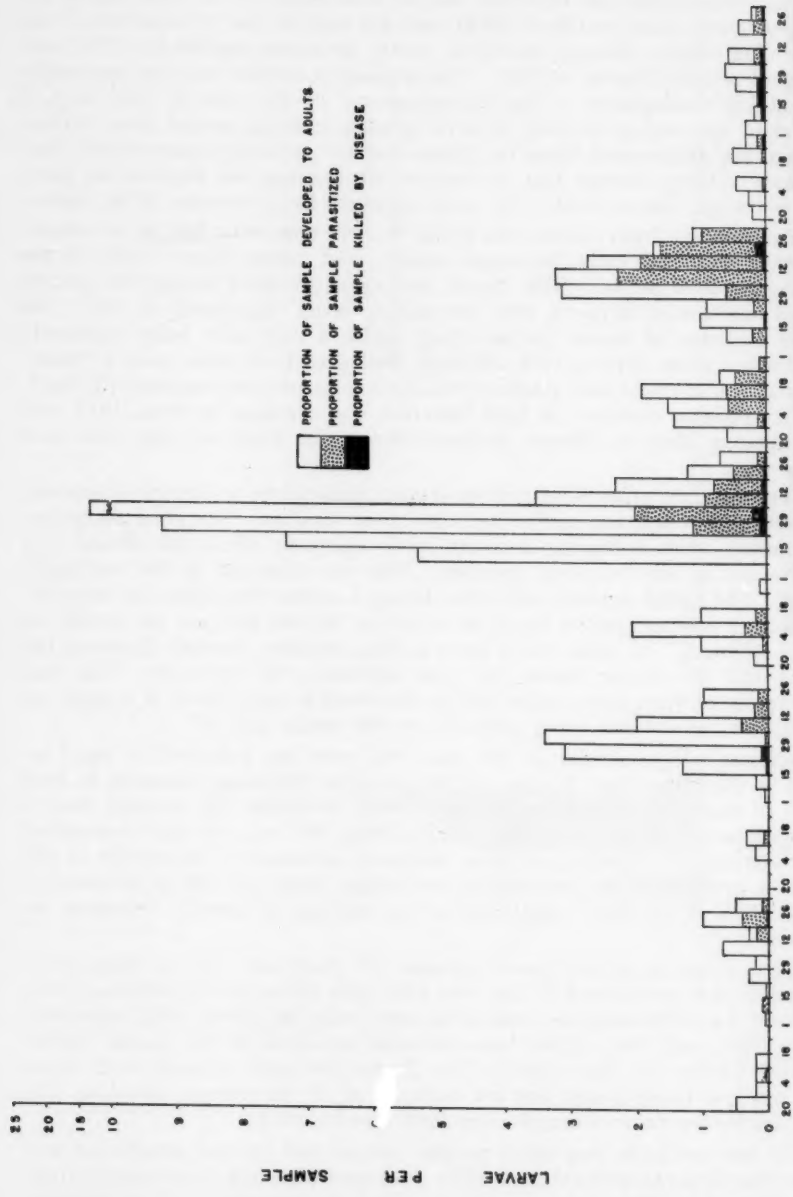
PROPORTION OF SAMPLE DEVELOPED TO ADULTS
PROPORTION OF SAMPLE PARASITIZED
PROPORTION OF SAMPLE KILLED BY DISEASE
LARVAE PER SAMPLE
JULY AUGUST SEPT. 1950
JULY AUGUST SEPT. 1951
JULY AUGUST SEPT. 1952
JULY AUGUST SEPT. 1953
JULY AUGUST 1954

Figure 3

TABLE I
Annual Summaries of Disease and Parasitism Based on Larval Samples

Year	Number of Samples	Larvae per Sample	Number of Larvae Reared	Percentage of Larvae Died From Disease	Number of Mature Larvae Reared*	Percentage of Mature Larvae Parasitized		
						Drino bohemica	*Exenterus vellicatus*	Total
1944.....	136	5.4	738	0.9	0	?	?	?
1945.....	324	4.9	720	63.8	181	39.2	13.8	53.0
1946.....	390	0.6	220	33.2	100	47.0	7.0	54.0
1947.....	482	0.3	100	3.0	69	33.3	7.2	40.5
1948.....	530	0.2	153**	1.9***	24	4.1	0	4.1
1949.....	490	0.7	281	0.7***	177	53.1	6.7	59.8
1950.....	500	0.3	155	0.6***	74	35.1	5.4	40.5
1951.....	400	1.0	423	1.2***	104	14.4	5.7	20.1
1952.....	400	3.2	1261	1.2	470	30.8	4.5	35.3
1953.....	420	1.7	698	7.8	326	58.5	9.2	67.7
1954.....	335	0.35	118	11.8	34	29.4	8.8	38.2

*Only fifth- and sixth-instar larvae are included in this column since the parasites seldom attack immature larvae.
**Larvae in addition to those collected in regular samples were reared.
***Larvae could have been infected accidentally since they died more than 5 days after collecting.

to the control of the sawfly apparent in 1945 and appear to have been chiefly responsible for maintaining sawfly populations at an extremely low level until 1951 when, for some unknown reason, the sawfly suddenly increased in numbers. The control of this "outbreak" is more obviously due chiefly to an increased activity of the parasites, especially in 1953 (Fig. 3). *D. bohemica* has been the most prevalent parasite species. *E. vellicatus* has also been obtained in considerable numbers (Tables I and II.).

TABLE II
Annual Summaries of Cocoon Parasitism

Year	Number of Sound Cocoons Collected	Percent Parasitism				Total Parasitism Percent
		Dahlbominus fuscipennis	*Exenterus* sp.	*Exenterus claripennis*	*Drino bohemica*	
1937.....	460	0	0	0	0	0
1938.....	1,048	0	0	2.0	0	2.0
1939.....	273	13.3	0	1.8	0	15.1
1940.....	45	0	0	0	0	0
1941.....	12	0	0	0	0	0
1942.....	10	0	0	0	0	0
1943.....	11	0	0	0	0	0
1944.....	46	0	6.5	0	6.5	13.0
1945.....	4	0	25.0	0	0	25.0
1946.....	0	0	0	0	0	0
1947.....	1	0	0	0	0	0
1948.....	2	0	0	0	0	0
1949.....	2	0	50.0*	0	0	50.0
1950.....	1	0	0	0	0	0
1951.....	7	0	14.5*	0	0	14.5
1952.....	21	0	9.5*	0	19.0	28.5
1953.....	26	0	19.2*	0	34.6	53.8
1954.....	4	0	0	0	0	0

N.B. — From 1937 to 1951 inclusive, cocoon sampling was done in May of the following year.
Exenterus vellicatus.

Conclusions

A virus disease and introduced parasites have been important factors controlling the European spruce sawfly in central New Brunswick. The virus has been very effective at high, and certain parasites very effective at low, host densities. Some species of parasites that showed ability to cause important mortality at high population levels have been replaced by species more effective at low population levels. The effectiveness of the virus has, until recently, appeared to be density dependent and to be independent of stress factors such as weather, overcrowding, and lack of food. The susceptibility of the sawfly to the virus appeared to be so great that if stress factors did add to it the addition was very minor and undetected. Recent increases in sawfly numbers from a very low to a relatively high population level without a subsequent rapid increase in larval mortality from disease suggests, for the first time, an increase in the resistance of the sawfly to the virus. At present, however, there appears to be little danger of a serious sawfly outbreak.

Acknowledgment

We wish to thank R. E. Balch, Officer-in-Charge, Laboratory of Forest Biology, Fredericton, N.B., for advice and guidance particularly during the early stages of the study, and officers of the Forest Biology Laboratory, and Laboratory of Insect Pathology, Sault Ste. Marie, Ontario, for their help in preparing this manuscript.

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The Use of Radioactive Cobalt in Studies of the Dispersal of Adult Females of the European Pine Shoot Moth, *Rhyacionia buoliana* (Schiff.)[1]

By G. W. Green[2], W. F. Baldwin[3], C. R. Sullivan[2]

This paper describes a successful attempt to tag adult females of the European pine shoot, *Rhyacionia buoliana* (Schiff.) with Co^{60}, chosen as a tagging agent because it is a gamma emitter with a sufficiently long half-life (5.3 years). Emphasis is placed on the preparation and application of the tracer material, the absence of immediately harmful effects of radiation on the insects, and the ability of the insects to behave normally with the tags in place. This work was undertaken in order to develop techniques for following the movements of large numbers of these insects.

Materials and Methods

The radioactive tagging substance was prepared by adding 2 millicuries of radioactive cobalt as nitrate to 1.5 cc. of an 8:1 'Bond Fast'[4]: water stock solution coloured with two drops of a saturated solution of methyl blue. The vial containing the tagging material was kept in a lead castle and this, in turn, was surrounded by a lead shield on the worktable. By viewing the source vial through a mirror mounted above and behind it, exposure of the operator's head and neck to radiation from the source during tagging was avoided.

Groups of four newly emerged females were anaesthetized with CO_2. The wings were spread forward from their normal resting position and held by insect pins in a shallow cork-bottomed box connected to a source of CO_2. The cobalt was applied to the dorsal abdominal surface with a fine camel's-hair brush to form a thin film of radioactive material about one-quarter inch long and one-eighth inch wide on the first seven abdominal segments. After the insects had been labelled, they were held under anaesthesia for about two minutes until the tags had dried, after which the moths were placed in individual shell vials closed with cotton plugs. One hundred and six insects were tagged for release in this manner. With practice, a team of three men, one preparing the insects for tracer application, one applying the tracer and removing tagged insects to their individual storage vials, and one testing the amount of radioactive material applied, could treat between 30 and 40 insects per hour.

When tested at a given distance from a Geiger probe and compared with a standard source, it was estimated that the majority of the insects carried between 25 and 50μc of Co^{60}. This amount of radioactivity can be detected easily in the field with a portable probe from a distance of at least 3 feet. Moths that could not fan their wings after application of the tag, or that carried less than 25μc of Co^{60} were discarded. These, however, amounted to only two of the 106 insects labelled.

The hardened tags adhered well to the abdominal scales. They did not hinder normal convolutions of the moths' bodies because flexion of the posterior portions of the abdomen, necessary for oviposition, merely loosened the scales in those regions affected. Strong adherence to the scales in the anterior portion of the abdomen was sufficient to keep the tags in place. The added weight of the tags did not appear to hinder normal flight. In addition, the wings,

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[4]A water-resistant resin glue manufactured by Le Page's Inc., Toronto, Ontario.

in the normal folded position when the insects were resting or crawling on the foliage, afforded protection to the tags.

The insects were labelled at Chalk River on July 10, 1956, and were released the following evening in the Sandy Hill Tract of the Waterloo County Forest near Elmira, Ontario. The release plot was a more or less isolated plantation of red pine trees of approximately 15 by 14½ chains (Fig. 1). The release was begun at 1845 hrs. E.S.T. on July 11, coincident with the beginning of the natural crepuscular flight period. The vials containing the tagged insects were placed in an upright position on a raised platform in the centre of the release area, and the cotton unplugged so that the insects could crawl out of the vials and take flight of their own volition. The majority of them succeeded in leaving the release table in this manner. However, one-half hour after the release was begun, a sudden thunderstorm with winds up to 18 miles per hour moved directly over the area. The wind carried most of the insects eastward through the plantation and, in fact, some of them were observed being carried into the adjacent fields.

Results

Daily observations of dispersal were planned, but inclement weather with high winds and heavy rains severely curtailed this program. Nevertheless, surveys were made with two Geiger counters during three periods within eight days of release. During the recovery program, living insects were not as a rule disturbed, but radioactive material such as dead insects, bird faeces, discarded tags, predacious animals, pine shoots and miscellaneous materials with high radioactivity indicating the presence of a tag were removed as found. This removal changed the effective total of released insects for each of the three recovery periods. Therefore, percentage recovery figures, as shown in Table I, were calculated on the changing effective totals of released animals.

The small difference between the percentage recoveries for July 12 and July 15-16 indicates that the insects tend to remain in the stand in which they were released, and that natural flight out of this stand during the early stages of the females' adult life is exceptional. The 60 per cent reduction in the tagged population during the first day of recovery cannot be considered typical since it was associated with adverse weather conditions during the release period. Some of the insects were carried out of the plantation by the high winds accompanying the thunderstorm during the release period, and others,

TABLE I

Recovery of radioactive material in the Elmira release area following the liberation of 104 Co^{60}-labelled adult females of the European pine shoot moth on the evening of July 11, 1956

Date (July)	Insects		Bird Faeces	Tags	Pine Shoots	Predators	Miscellaneous	Effective** Total	Per Cent Recovery
	Alive	Dead							
12	39*	0	2	1	0	0	0	104	40.4
15-16	28	2	4	0	6	1	1	98	42.9
18-19	7	1	0	0	12	1	1	84	26.2

*Three of these females found in copulation on July 12 were removed for oviposition studies. One of them was damaged in removal and was discarded.

**Effective total — theoretical number of tagged insects left after removal of radioactive contacts during each survey period. For example, 6 contacts (3 insects, 1 tag, and 2 bird faeces) were removed on July 12 reducing the effective total for July 15-16 to 98.

weakened by exposure to the wind and rain, may have been easier prey for foraging ants and birds. The decrease by July 18-19 may be considered normal and may be due to the increasing tendencies to flight as oviposition progresses (Green, unpublished) causing the moths to leave the area, as well as to normal

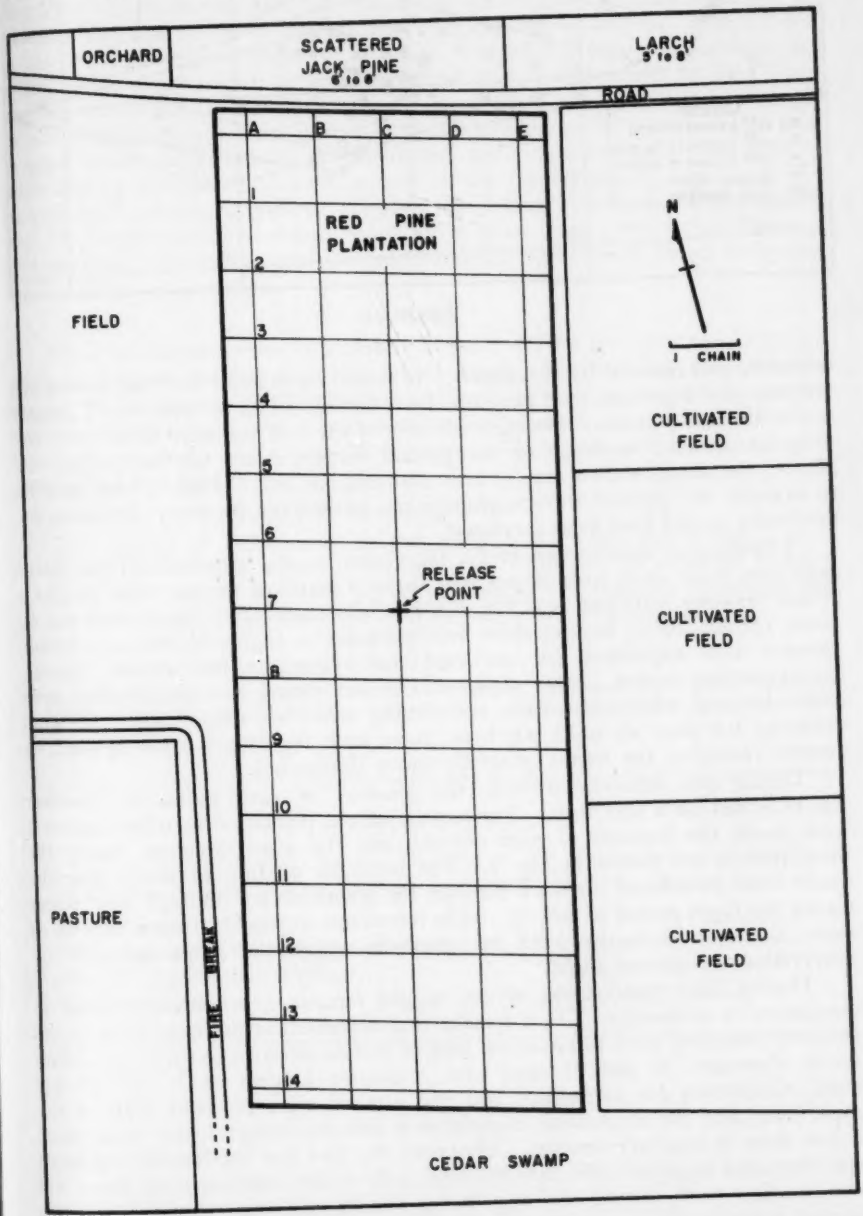

Figure 1

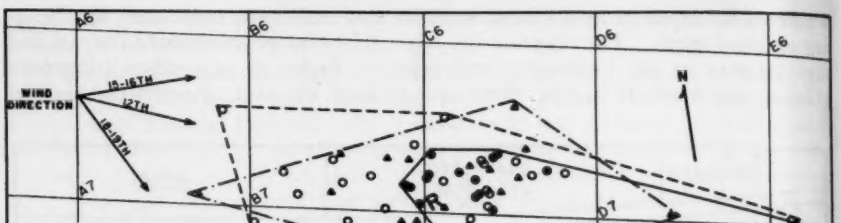

Figure 2

mortality and removal by scavengers. It should be pointed out that radioactive contacts at the ground level have not been considered in the recovery estimates or the dispersal patterns. Owing to the size of the area examined in the recovery program, detailed coverage of the ground surface could not be carried out. Hence, the results shown are for tree examinations only. Had it been possible to examine the ground surface closely, the percentage recovery estimates undoubtedly would have been increased.

Unpublished observations of G. W. Green on the behaviour of the European pine shoot moth have shown that flight is confined for the most part to a period between 1800 and 2030 hrs. E.S.T. Like those of *C. fumiferana* and *C. pinus* (Smith, 1954), females show little tendency to flights of any considerable distance until copulation has occurred and oviposition has started. During the oviposition period, flights of up to 150 feet during any one evening have been observed while the moths are visiting trees for oviposition. At wind velocities less than six miles per hour, most such flights are made upwind; at greater velocities, the moths generally move downwind.

During the recovery periods, the location of each radioactive contact was recorded on a base map. The section of the plantation in which contacts were made, the location of each contact, and the wind direction during the three periods are shown in Fig. 2. The recovery of July 12 shows that the moths were distributed eastward through the plantation by the high west winds during the flight period of July 11. The recoveries on July 15-16 and July 18-19 show movement into the wind for distances within the range indicated by observations on natural flight.

During field observations, several tagged females were observed either in copulation or oviposition. Two females that copulated in the field were placed in cellophane-lined petri dishes at the base of one of the trees in the area. These moths deposited 39 and 42 eggs with respective hatches of 25 and 86 per cent. Conditions for oviposition and egg survival were far from ideal in this experiment and the oviposition complements and percentage hatch were much below those in insectary rearings. However, the fact that the females copulated and deposited eggs indicates that the tags, and/or the radiation from them, did not interfere with mating and egg laying, which otherwise would distort the normal flight activity. Incidentally, this also indicates that radiation from 25

to 50 μc of Co^{60} for the period involved was not sufficient to prevent the the production of viable eggs.

During the recovery period, 18 radioactive pine shoots were found. In some of these, no particles of the radioactive tags could be visibly detected, and in a few instances, radioactivity could be traced to individual needles. In addition, two specimens of the bladder campion, *Silene latifolia* (Mill.), listed in the 'Miscellaneous' column of Table I, yielded high counts between the nodes. This suggests that radioactive cobalt had been leached by rain from tags and subsequently absorbed into the plant tissue. If leaching does occur, even though small quantities of radioactive material may be absorbed and held in plant tissue (where they can be located easily and manually removed), a good deal of radioactive material missed during the recovery programs would be dispersed and carried into the soil, thus minimizing its hazard. This, coupled with the foraging activity of ants, would be of great help in the decontamination of test areas. For this reason, the water-resistant qualities of 'Bond Fast' glue are currently being studied.

Summary

These studies show that a radioactive tracer (Co^{60}) can be successfully applied to adults of the European pine shoot moth. The fact that tagged moths are capable of normal flight-behaviour is shown by the results of recovery of radioactive individuals. As far as could be ascertained from this preliminary work, the tags had no effect on the behaviour, life expectancy, or reproductive processes of the insects.

Acknowledgements

The tagging of insects used in this study was carried out at the Atomic Energy of Canada Ltd., Chalk River, Ontario. The authors are very grateful to Dr. C. A. Mawson for valuable advice during the tagging operation, and for the loan of the Geiger counters used in the recovery program.

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ANNOUNCING:

The Ninety-fourth Annual Meeting of the Entomological Society of Ontario will be held at Queen's University, October 24-26, 1957.

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Guelph, Ontario.

A. S. WEST, *President*,
Department of Zoology,
Queen's University,
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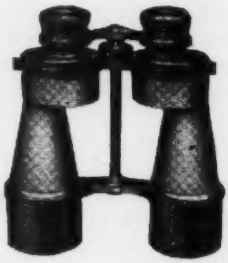

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the early afternoon. In the evening of the same day the DDT-malathion dust, parathion emulsion and parathion dust were applied.

Early the next morning there was a light rain followed by very heavy precipitation about noon (0.65 inches precipitation occurring in one hour). A strong wind occurred during the storm.

Effect of Treatments on Vertebrate Population

Examination of the various areas by a representative of the Game Management Division of the Conservation Department disclosed no effect on the vertebrate population which could be attributed to the insecticides.

Evaluation of Kill

Under the crown of each of the marked trees, a glass plate twelve inches square, previously coated on one side with Tanglefoot, was set on the ground to catch falling scale crawlers. The first group of plates was distributed just before application and left for 24 hours after the treatment was applied. A second set of plates was then set out which was taken up forty-eight hours later. To facilitate counting scales, the plates were placed over a grid of one inch squares. Since smearing had occurred on the edges of some plates, no counts were made in the border inch. As the sample size which would give the most precision for the labor expended was unknown, ten one-inch squares were chosen at random on each plate and the crawlers counted, since this could be easily handled statistically.

Data from the plates exposed during the first 24 hours, those exposed for the following 48 hours, and the combined totals per point were analyzed by the analysis of variance using a completely random design. In each, results between treatments were highly significant. Duncan's Multiple Range Test showed that for the 24-hour exposure, malathion dust, DDT-malathion emulsion, and malathion emulsion were significantly better in dropping crawlers than all the other treatments. There was no significant difference between these three at the 95 per cent probability level.

When applied to the data from the following 48 hours this Range Test showed that the parathion dust area was the only one with significantly higher crawler drop than all other areas. In the DDT dust area the number of crawlers caught was significantly lower than the rest. However, this plot was at one end of the experimental area and the low crawler drop may possibly have been due to the direction from which the wind came at the time of the thunderstorm.

Malathion dust, DDT-malathion emulsion and malathion emulsion caused as great a crawler drop in the first 24 hours as in the following 48 hours, indicating that the insecticides were sufficiently toxic to produce rapid kill. Except in these three treatments, the crawler drop increased, after or during the rain, by a factor of three. This increase was evidently due to something other than the insecticides, since it occurred on untreated as well as treated areas. The total drop of crawlers in the parathion dust area during the 72 hours compared favorably with the crawler drop in the areas to which malathion dust, DDT-malathion emulsion and malathion emulsion had been applied.

Relation of Mature Scales to Crawler Drop

Analysis of covariance (Snedecor 1953) indicated no significant relationship between numbers of mature scales present in different plots before spraying and numbers of crawlers dropped in the 72-hour period after spraying. Furthermore, there was no significant relationship between numbers of crawlers dropped within 72 hours after spraying and the numbers of crawlers found on the new growth before spraying.

Design of the Experiment

Reanalysis of the data showed that with a similar scale population the precision of such an experiment could be increased by placing more plates and counting fewer squares. Precision is increased by five per cent (Precision Factor = 105) when ten squares on ten plates are counted as compared with five squares on ten plates. The precision would be increased by 100 per cent (Precision Factor = 200) if four squares on twenty plates were counted instead of ten squares on ten plates, although other factors, such as time required to prepare and set out plates versus time required in counting crawlers on plates, would have to be taken into consideration.

Conclusion

Of the insecticides tested, malathion emulsion was the most effective per unit cost for use against crawlers of the pine tortoise scale.

Summary

During the summer of 1954 a project to determine methods for controlling the pine tortoise scale, *Toumeyella numismaticum* (P. and McD.), was undertaken jointly by the Wisconsin Conservation Department, the Marinette County Forestry Board and the University of Wisconsin. Control was necesasry to protect the financial investment in certain jack pine plantations. The main host for this scale is jack pine. A few jack pines show resistance to the scale, as do nearly all red pines.

The crawler stage of the scale was most susceptible to insecticides. Laboratory tests against the crawlers were made with malathion, parathion, DN-289, systox, endrin, Ovotran, DDT emulsion, DDT technical, DN-111, aldrin and lindane. The first four insecticides proved more effective than the others.

Parathion, malathion and DDT in emulsion and dust form were selected for experimental field trials. Results of field treatments were evaluated from counts made of crawlers which dropped onto glass plates coated with Tanglefoot. Malathion emulsion was the most effective insecticide per unit cost for use against crawlers of the pine tortoise scale. The correct time for application of insecticides is at the time of maximum crawler hatch.

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